International Health Exhibition,

LONDON, 1884.

THE

HEALTH EXHIBITION LITERATURE.

VOLUME IV.

HEALTH IN DIET.

HANDBOOKS.

PHYSIOLOGY OF DIGESTION AND THE DIGESTIVE ORGANS.

THE PRINCIPLES OF COOKING.

DIET IN RELATION TO HEALTH AND WORK.

FOOD AND COOKERY FOR INFANTS AND INVALIDS.

ALCOHOLIC DRINKS.

WATER AND WATER SUPPLIES; AND UNFERMENTED BEVERAGES.

SALT AND OTHER CONDIMENTS.

PRINTED AND PUBLISHED FOR THE

Executive Council of the International Health Exhibition, and for the Council of the Society of Arts,

BY

WILLIAM CLOWES AND SONS, LIMITED,

INTERNATIONAL HEALTH EXHIBITION,

AND 13, CHARING CROSS, S.W.

1884.

LONDON:
PRINTED BY WILLIAM CLOWES AND SONS, LIMITED
STAMFORD STREET, AND CHARING CROSS.

HANDBOOKS.

PREFACE.

THROUGHOUT the whole range of subjects connected with the Public Health, there are none which possess greater interest and importance than those which deal with Food and with Diet, in their various aspects. To an ignorance of the first principles of dietetics we must ascribe a very large proportion of the sadly too numerous infantile deaths in this and other countries; much of the discomfort and ill health, and, indirectly, of the vice amongst the adult members of our population; and much lavish waste impoverishing individuals and communities.

Modern science has already solved many of the most important problems connected with diet. It has shown that the food which we consume is not only destined to supply the never-ceasing waste of matter which is one of the most characteristic features of life, but the *energy* whose transformations are necessary to, and are the very essence of each vital act. It has taught us "the why and the wherefore" of much which man has acquired by long transmitted experience, furnishing us, however, with criteria whereby we may test the dicta of mere empiricism. It has supplied us with the means of ascertaining the composition, testing the relative purity, and determining, in a sense, the theoretical value of the constituents of our diet, and with methods which, when they shall have been utilised as completely as possible, will teach us how to employ the matter and energy available by man, in the manner most economical to the individual and the race. The magnificent researches of Professor v. Voit, of Munich, and his school, have indeed already in great measure

supplied us with this information. We do not know in studying these researches whether most to admire the perseverance, the sagacity, or the fruitfulness in resources, manifested in these endeavours to study the tissue changes in living beings under the most diverse conditions, and which have, indeed, already furnished the principles which may safely guide us in selecting diets which shall prove adequate under different conditions.

Whilst science has solved many problems of great complexity relating to the food of man, there are certain questions full of interest upon which, however, the light which she throws is but dim, and insufficient to guide us. Whether, for instance, the addition of a small quantity of alcohol to the diet consumed by man is of benefit, or a source of danger or positive injury to him, is a question full of interest to the conscientious man, and especially to the conscientious physician, but which pure science leaves as yet entirely unsolved.

The essays which have been brought together in the present volume appeared during the recent Health Exhibition as separate Handbooks on the subjects of which they treat. Of these, some deal with scientific principles and facts, a knowledge of which is the basis of all proper study of diet; others give a scientific account of particular articles consumed by man, whilst some deal with the processes whereby food may be best prepared for the use of man in health and disease.

It is hoped that these short treatises may supply numerous readers anxious for elementary knowledge on matters connected with health, with much exact information which would otherwise not be accessible to them, and that they may thus assist in the great object of the Exhibition of 1884, viz., the diffusion of knowledge which shall promote the health of our fellow creatures.

ARTHUR GAMGEE.

November, 1884.

PHYSIOLOGY OF DIGESTION

AND THE

DIGESTIVE ORGANS.

BY

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CONTENTS.

LECTURE I.

LECTURE II.

LECTURE III.

PHYSIOLOGY OF DIGESTION.

LECTURE I.

GENERAL INTRODUCTION.—THE LOSSES OF THE ANIMAL BODY.—THE NATURE OF FOOD.—THE PRINCIPLES OF DIETETICS.

If we study attentively the living animal body we come to the conclusion that it is continually wasting, and that every vital act is associated with, and necessarily dependent upon, a certain loss of matter. If, for instance, the animal body were placed in one scale of a balance-pan, and its weight determined at one particular moment, if the balance were sensitive enough we should find the next moment that the weights which exactly counterpoised the animal no longer did so.

Let us consider the causes of this loss of weight. I blow through a glass tube into the lime-water contained in this glass, and you observe that the perfectly pellucid and clear lime-water becomes more and more milky; and if I place the glass aside for a few moments, there will fall a deposit consisting of calcium carbonate. This experiment affords the simplest way of showing that one of the sources of loss of the animal body is due to carbonic acid which is continually being evolved by it. I now draw your attention to the bell-jar on the lecture table, below which you observe a living guinea-pig. Arrangements have been made for drawing a stream of air through the bell-jar. In its passage to the bell-jar the air has to bubble through a vessel containing lime-water, and again on its exit from the bell-jar the air bubbles through a second similar piece of apparatus.

Observe that whilst the lime-water in the first vessel is only feebly opalescent, indicating that the air contains but a small quantity of carbonic acid, the lime-water contained in the second vessel is becoming more and more turbid. This experiment is, as you will admit, more satisfactory and more instructive than that of simply blowing through lime-water, for it teaches us that the carbonic acid which is thrown off by the animal body is actually produced within it. We might readily modify the simple respiratory chamber in which the guinea-pig is now placed so as to permit of our determining the *amount* of carbonic acid which is produced by it in any given time. We might for instance pass the whole of the air which leaves the chamber through a weighed receptacle containing some substance such as caustic potash or caustic soda, which possesses the power of absorbing and combining with carbonic acid: such determinations have been made in the case both of the lower animals and of man, and to certain of the results obtained in this way I shall afterwards direct your attention. Now the carbonic acid which has been produced by the body of this guinea-pig and whose presence is attested by the opalescence of the lime-water is thrown off in the greatest part by the respiratory organs, the lungs, and also in some measure by the skin.

Amongst the chief continuous losses of the body is that of watery vapour. Under ordinary circumstances we do not appreciate that no small quantity of water is continuously passing off from our lungs and respiratory passages, together with the carbonic acid. When the temperature of the external air falls very low, the presence of water is, however, rendered perfectly obvious to our senses by its immediate condensation as the breath meets the air, and by the deposition of water upon cold surfaces, as, for example, upon windows of confined and imperfectly ventilated rooms, in which human beings or other living animals are confined.

By again modifying our apparatus we might in the case of this guinea-pig determine the amount of water passing

as watery vapour into the air which traverses the chamber. I shall afterwards have to consider with some degree of care the statistics of the animal body, and to bring before you the actual amounts of the losses which the body daily sustains, but at present, without going into details, I wish to impress upon you the fact that, as it lives the body of necessity loses large quantities of matter, amongst the chief of which are carbonic acid and water. The amounts of these substances are not, I may add, constant quantities, but depend particularly upon the weight of the body, upon the amount of food consumed in a given time, and upon the amount of work done by the body.

Leaving the animal body for the present, let me direct your attention for a moment to the phenomena of combustion. To the bent wire which I hold in my hand I have attached, as you observe, a small wax taper which I light. I plunge the taper into a glass gas-jar with narrow neck standing over water, and we observe that at first the taper burns vividly. As it continues to burn a little water is condensed on the sides of the jar, but now the flame begins to grow fainter. The light evolved diminishes ; and, as I speak, the flame is extinguished, or rather just about to be extinguished, for on rapidly drawing the taper into the air, the yet smouldering wick bursts into a flame again, which is extinguished however completely, if, as you now see me do, I re-plunge the taper into the gas-jar and leave it there. As the taper burned, there has been produced water, which in part is evident to our senses in the dew which has condensed upon the sides of the vessel, and large quantities of carbonic acid, which, like the carbonic acid evolved by breathing animals, is not obvious to us unless we have recourse to some simple chemical method of demonstrating its presence. How much carbonic acid is produced during the combustion of a taper similar to that used in the last experiment, is obvious to all when I pour some lime-water into this stoppered bottle, in which a taper was burned to extinction. The abundant precipitate of calcium carbonate again testifies to the fact which I wish to demonstrate. In the

process of combustion a candle, then, has produced carbonic acid and water, and, as you all see, its substance has diminished. So rapid is the process of combustion in this case that the diminution in the mass of the burning body needs no balance in order that we may detect it.

The process of combustion as it is illustrated by this burning candle consists in an active and rapidly progressing oxidation of the burning body. The latter is in the case of the wax taper composed of organic chemical compounds rich in carbon and hydrogen, and containing but little oxygen. The carbon and hydrogen uniting with the oxygen of the air form carbonic acid and water, and in doing so there is evolved heat so intense as to produce visible light, which is associated with this particular act of combustion. The products of combustion in this case are carbonic acid and water.

The animal body, like the candle, consists in great part of organic chemical compounds. As the animal lives, its substance burns, that is, oxidises. The carbon and the hydrogen of its organic compounds combine with oxygen and give rise to carbonic acid and water. Though the magnitude of its operations may be, and often is, very great, the intensity of the process of combustion at any one moment, is not, however, such as to be rendered obvious to our senses by the evolution of light, although, as I shall afterwards more particularly point out, it is accompanied by the evolution of very much heat. It will serve to impress upon your minds how great is the analogy between the greatest, and if I might so say, final chemical operations of the animal body and the combustion of a candle, if I show you another experiment relating to this division of my subject. Standing in a basin containing water is a gas-jar, having a capacity of about a quart. This gas-jar is fitted with an india-rubber stopper perforated in its centre so as to admit an accurately fitting glass tube to which is attached an india-rubber tube, which I shall afterwards introduce into my mouth. At present the gas-jar contains air having the composition of the air of the room, and, therefore, able to

support animal life and combustion. Were I to place a burning taper in the jar it would, as in the previous experiment, burn for some minutes until the greater part of the oxygen of the air had been removed or replaced by carbonic acid. Placing, however, the elastic tube connected with the gas-jar into my mouth, I now make a forcible inspiration, so as to draw the whole of the air which it contains into my lungs and air passages. Immediately thereafter, by a forced expiration, I expel the water which has been drawn into the jar into the basin, and the jar now contains atmospheric air modified by its passage through the lungs. I now light a taper and plunge it into the jar. You observe that the flame is instantly extinguished, indicating that, in the process of respiration, the air which has passed through the lungs is so modified that it will no longer support the combustion of combustible bodies : that it has been modified in the same manner as it would have been by a combustible body burning until combustion was no longer possible.

It was the great French chemist Lavoisier, who, in the last century, co-ordinating facts which had been ascertained by our countrymen Mayow, Black, Priestley, and others, and adding a great many which he himself had discovered, established the remarkable truth that the process of respiration in animals is essentially the same as the process of combustion. He ascertained that the chief products of respiration of the animal body were identical with the products of combustion of the substances chiefly used as fuel, and he asserted that the heat of the animal body is, like the heat produced in ordinary combustion, due tó the chemical union of carbon and hydrogen with oxygen. This great philosopher, however, committed the mistake of localising the combustion of the animal body in the lungs. It was in these organs that he surmised the blood to be heated, and hence the heat of the animal body to be distributed. We now know that the living animal body is everywhere the seat of oxidation processes, which result in the production of carbonic acid and water ; these chemical processes being, however, more intense in those organs in which vital

processes are most active; while the processes which go on in the lungs are recognised as being essentially processes concerned in the interchanges of gases between the air on the one hand, and the blood on the other.

We may therefore say with strict accuracy that the human body from hour to hour is consumed like a candle; the combustion in the candle is rapid and luminous, and occurs only in conditions of high temperature; that of the body is slow, non-luminous, and takes place in the comparatively cool wet tissues; nevertheless they are essentially similar, in that in both cases the combustion is supported at the expense of loss of substance, and at the cost of the oxygen of the air; and in both cases new substances are evolved by the combination of the latter gas with the matter of the burning body.

The points of difference must be sought in the dissimilarity of the substances which are burned. The fatty or waxy matter of the candle is a compound of C, H, and O, which can only yield bodies containing these elements with the O of the air; such are the CO_2, and the H_2O, whose formation during combustion has already been demonstrated. On the other hand, there is no tissue of the human body which does not contain, as essential constituents of their structure, complex nitrogenous bodies. In the muscles, in the glands, in the brain, in the blood, in all the parts which we are accustomed to regard as characteristic of a living body, N is found as a constituent of the very first importance. We are not surprised, then, that N-holding bodies, like the carbonaceous, fall victims to the all-devouring fire of life, and are represented in the class of substances evolved in its combustions. In other words, the body of an animal evolves CO_2, and H_2O, just as does the burning candle; but in addition it evolves a body, or bodies, containing N. Of these urea (CH_4N_2O) may be taken as the type; it is excreted by the kidneys and also to a small extent by the skin.

We are now in a position to inquire more particularly, what are the total losses of an average human body in the course of 24 hours?

It has been estimated that the body loses in 24 hours about [illegible] lbs. of water and rather over [illegible] lbs. of other matters, of which the chief is carbonic acid. The amount of carbon corresponding to the carbonic acid amounts in 24 hours to [illegible] grains. The amount of nitrogen amounts to about [illegible] grains.

But if a body loses [illegible] lbs. in weight every 24 hours, it is a simple calculation to ascertain how speedily that body would be reduced to nothing. The losses must be daily repaired: new matter must be added to counterbalance that which is lost, and the obvious source of such renewal of substance is the food we eat and the water we drink. From this consideration there arise important questions: Is it the daily supply of food which is consumed in the body? Is the body as it were the lamp and the wick, and the food that we daily eat the oil for the lamp? Does the body really correspond to the candle itself suffering combustion,—or is it not rather the candlestick containing the consuming substance? There is [illegible] to be said for this view of the matter suggested by these questions. The well-nourished body of a healthy man contains besides the indispensable [illegible] which [illegible] existence from moment to moment [illegible] other tissues [illegible] stores [illegible]. The lamp is furnished with a reservoir of oil enough to feed its flame in the absence of the usual daily replenishing. Such a store in the body is the fat which fills up the hollows of the frame and gives the plump appearance to those who are physiologically speaking well-fed. But besides this, much substance contained in other parts, even in important and indispensable organs, such for example as the muscles, may be regarded as stored material available for future consumption in case of need. Hence when an animal is deprived of all food it does not at once die—the flame does not forthwith flicker down and expire—but the combustion proceeds, though much reduced in intensity, and the excretory substances are evolved and cast forth as formerly. Meanwhile the tissues of the body [illegible]

reinforcement, dwindle rapidly, but not equally ; and when the body has been thus reduced in weight by a certain proportion which is almost constant for each kind of animal and each phase of life, death ensues ; the oil has been spent, and there is nothing but the empty lamp remaining.

Of all the tissues of the body, the fat is that which wastes the most quickly during starvation ; it may even disappear entirely. The liver, which also is a large storehouse for the rest of the body, yields up its store completely. The muscles, except that of the heart, supply fuel to the struggling flame ; and even the blood loses much of its substance. The brain and spinal cord alone preserve their weight during complete starvation, and seem to have no portion that can be made to serve as fuel for the body at large.

We see, then, that so long as life continues, whether food be taken or not, the body, moment by moment, loses weight ; when loss ceases, life ceases. But loss of weight is not the only loss the body momently suffers. In addition to loss of substance, there is a continuous loss of energy.

The Energy of the Body.

Thanks to the lucid expositions of many brilliant teachers, the popular mind is beginning to attach clear notions to this term *energy*. Nevertheless, some illustration of its meaning in connection with the life of our body, may not seem superfluous. *Energy*, in the technical sense in which I use it here, may be translated into *the power of doing work :* and the loss of such power of doing work seems to be as inseparably associated with our conception of living matter as the loss of substance has been shown to be. How may loss of energy be exhibited by a body ? If I were to take a large solid iron ball and heat it in a furnace to redness, and suspend it by a chain from the ceiling of a lofty room, the ball would sooner or later grow cold : it would give up its heat to the bodies or the space surrounding it—in other words, it would *lose* heat. But at the same time, and in the same degree, it would lose the power of

doing work. The power which a red-hot cannon-ball possesses of doing work, is one which may be readily demonstrated. If such a ball be plunged into a cauldron of cold water, the energy (*power of doing work*) which is continually streaming from all parts of its surface is caught up by the water, and might be utilised by a simple apparatus to do the work of a steam engine. When the ball is cold once more, this power of doing work is gone.

Take another example. When I wind my watch up at night, I impart to the coiled spring a certain quantity of energy—of power of doing work—which slowly dribbles away at every click in the ceaseless motion of the wheels. In 24 or 36 hours the watch has lost all its power of doing work—its energy has escaped from it. If by chance the main-spring snaps, suddenly the whole energy escapes in a second or two, with the well-known whirring of such a disaster. Again, a charge of gunpowder, or a charge of dynamite, in the interior of a bomb, possesses an enormous power of doing work. Such energy might conceivably be allowed by a proper mechanism to escape little by little in a somehow useful manner: we all know, however, with what destructive violence such a body commonly parts with its stored-up power of doing work.

I may at once point out a distinction which it is convenient to draw. If I wind up a clock much energy or power of doing work becomes latent in the spring. If I omit to set the pendulum swinging, the energy remains latent for an indefinite time: the clock possesses the potentiality of doing work; its energy is *potential*. When the pendulum begins to swing, the 'escapement' allows the pent-up steel to unroll itself gradually bit by bit: work is done, the power of doing work is operative, the energy is *actual* or *kinetic*. All energy belongs to one or other of these two classes. The energy of the red-hot ball is actual; that of the explosive before ignition is potential.

Now a living body, say of a man, as has been said, is as continuously losing energy as it is losing matter and weight. We observe this in many ways. In the first

place, the body is the seat of movements, some of which are voluntary and others involuntary. The being whom we are studying may, in virtue of the contraction of his muscles, perform work which we may estimate. The amount of work done in a working day of 24 hours may actually amount to 150,000 kilogramme metres, that is to as much work as would be required to lift nearly 480 tons to the height of one foot. But assuming that the human being which we are studying is not exerting any voluntary muscular effort or doing any external work, we may yet observe that it is the seat of movements which are unceasing, and whose continuance is absolutely essential to life. The movements of respiration and the contractions of the heart are the most obvious of these.

If our study be an exact and not a superficial one, we shall come to the conclusion that the marvellous pump, the heart, which is ceaselessly engaged in driving blood throughout the body, is performing an amount of work which might be estimated without exaggeration as at least equal in 24 hours to the work expended in lifting 120 tons to the height of one foot, while almost certainly it would greatly exceed this estimate, that is to say, that the heart of a person who is almost absolutely at rest does an amount of work which is a sensible fraction of the *external*, or, to use a popular expression, the *manual* labour performed in the working day of a hard-working labourer.

Next to the movements voluntary and involuntary which we are just considering, the heat of the animal body attracts our attention. If with a thermometer we observe its temperature, we are made aware of the marvellous fact that so long as it is in a state of health the temperature of the body is nearly constant, and that the temperature is very much above that of the medium which surrounds the body, varying between 98° and 100°. If we plunge the body under observation into a cold bath surrounded by non-conducting materials, or if instead of plunging the whole body we simply experiment upon a part of the body, for example one of the lower extremities, we ascertain that

by contact with the body the water becomes heated, and if we determine the amount of water raised in temperature, and the amount of the increment of temperature, we obtain an estimate of the loss of heat sustained by the body. We may thus determine that the human body under observation loses in 24 hours an amount of heat which corresponds to that required to raise, say 2,400 kilogrammes of water one degree Cent., or in other words to raise about 50 pounds of water from freezing point to boiling point. If we appeal to the experience of the physician and to the experience of mankind, we are told, too, that this normal temperature of the animal body is a necessity for its continued existence, and that were the temperature of the body to be permanently lowered to any considerable degree, the functions which are most essentially vital, that is, most necessary to the continuance of life, cease, and death ensues.

We now approach the question of the source wherein our store of matter and of energy in the body is continually replenished. *Ex nihilo nihil fit*: a body which continually loses substance and yet maintains its weight, and a body which, while continuously losing energy, yet retains its power of doing work, must depend upon the introduction of new matter and new energy from without.

The substances lost are retrieved, as must be obvious to the simplest child, in the food which is eaten: it is equally true, although not so obvious, that the lost energy is recovered from the same source. In short, the substances which enter the body have not the same form as the substances which leave it: starch, albuminous matter, fatty matter, are introduced as food; but carbonic dioxide, water, urea, are the representatives of these substances in the excretions. Similarly the energy which enters the body is (with trifling exceptions) unlike that which escapes: in the former case it is *potential*, in the latter it is *actual* or *kinetic*. And these two concurrent series of events, viz. the transformation of matter on the one hand, and of energy on the other, are inseparably associated. Matters are introduced into the body in one chemical form and

while there are converted into other and more stable forms: and in the course of this transmutation actual energy of heat and mechanical movement appears and escapes. If you ask me what is the general nature of these chemical changes out of which so much energy appears which before was latent or potential, I can refer to that cardinal comparison with which I started, viz. the comparison of the living body to a burning lamp, and tell you that the chemical changes which are linked at every step to the manifestations of life are oxidations of a more or less evident kind.

Here, then, we have the explanation of the continuous wasting and renewal of the body: there is no life (in our physiological experience of it) without the conversion of potential into actual energy: there is no such conversion without the chemical transmutation of unoxidised or partially oxidised matters into matters more perfectly oxidised: there can be no such oxidation without the continual renewal of the factors of it, and the continual removal of the effete substances.

Whilst certain of the losses of the body are absolutely continuous, to wit the loss of carbonic acid and a portion of its water, other of its losses are, as it were, intermittent, these matters being accumulated in proper receptacles and then thrown out of the economy.

Like the losses, the gains of the matter of the body are in part continuous, in part intermittent. For instance, the body is without ceasing receiving oxygen gas which in the case of air-breathing animals is derived from the atmosphere which they breathe, and in the case of aquatic animals from the air dissolved in the water which they inhabit, the oxygen which is being continuously received by the body being very nearly, though not exactly, equal in amount to the carbonic acid which is being simultaneously expelled by the process of respiration.

The intermittent sources of gain of the animal body are constituted by the food and drink which from time to time are introduced into it. Of all the constituents introduced

in this way. By far the most abundant is water, which constitutes not only the greatest part of the liquid, but which is also present in considerable proportion in all those solid articles of food which we consume. Besides water, the food contains certain mineral constituents, amongst which may be mentioned as most important common salt, whose presence in and passage through the animal body and its various tissues and organs appears to be absolutely essential to a variety of the chemical and especially physical processes which have their seat in these. The solid constituents of food contain, however, as their principal constituents certain organic bodies belonging to few perfectly defined groups, and which are of such a nature that they or their derivatives may in great part be so acted upon as to enter into and become as it were part and parcel of the various tissues and organs, in other words be assimilated.

There are, it will be observed, very close analogies between the animal and such a piece of mechanism as the steam engine. Thus the energy at the disposal of both is primarily derived from the oxidation of combustible matters. Again, the potential energy latent in the combustible matters and the oxygen to which as yet it has no suitable access, appears as heat and mechanical movement in both. Some of the most salient points of difference must, however, not be lost sight of.

(1) The waste of the essential parts of such a machine as the steam engine is insignificant, and bears no definite relation to the work done. The kinetic energy of the machine is primarily due to oxidation processes taking place in the furnace, and in no respect to changes in the substance of the machine. The animal, on the other hand, wastes continuously in all its parts and organs, and its energy is derived immediately from material which has become part and parcel of the various mechanisms.

(2) Any substance capable of being readily oxidised (burned) and thus of generating heat may be used as fuel in the steam engine, provided its oxidation admits of being

conducted with safety to its furnace, whilst the substances which can form the food of animals belong to few groups which include but a comparatively small number of bodies. The constituents of food have not only to supply energy to the body but they must further be capable of prior conversion into the very substance of the animal body, into its very "flesh and blood." Moreover the constituents of food must be very free from traces of the peculiar substances which we term poisons, and which by their presence have the power of impairing and stopping the action of various organs of the body, and in this way terminating life.

Let us now return to consider what are the losses of the matters of the body in 24 hours. An average human body loses in 24 hours of water about 40,000 grains or 6lbs.: of other matters about 14,500 grains, or over 2lbs. The latter contains carbon, mostly in the form of carbonic acid amounting to 4000 grains, and nitrogen excreted mainly in the form of urea amounting to 300 grains; the ratio which the nitrogen bears to the carbon excreted, namely 300 to 4000, or roughly 1 to 13, is a number which I would ask you to remember. The table to which I now direct your attention illustrates the channels through which the water, the nitrogen, and the carbon, are severally excreted.

——	Water.	Other matters.	N.	C.
	grs.	grs.	grs.	grs.
Lungs	5·000	12·000	..	3·300
Kidneys	23·000	1·000	250	140
Skin	10·000	700	10	100
Fæces	2·000	800	40	460
Total .	40·000	14·500	300	4·000

Now in order to make up for this loss the body must daily receive about 8000 grains of solid dry water-free food, about 36,500 grains of water, and about 10,000 grains of oxygen, the latter being introduced into the body in the process of respiration.

The Food of the Animal Body the source of its Energy.

We have now to consider more particularly than we have yet done the nature of the solid food which the body requires. In the first instance this solid food, in order conveniently to support the body, should contain the elements carbon and nitrogen in approximately the same proportion as these elements are contained in the matters excreted by the body. In the second place, as has been already stated, these elements must be contained in chemical compounds belonging to a few tolerably well-defined groups.

The organic matters of the foods may be divided into nitrogenous and non-nitrogenous. The former containing the elements carbon, hydrogen, nitrogen, sulphur and oxygen. The latter only the elements carbon, hydrogen and oxygen. All these organic matters, whether they be nitrogenous or non-nitrogenous, are primarily derived from the vegetable kingdom.

The Plant in reference to the Animal.

The plant is the necessary and constant precursor of the animal. The plant organism possesses synthetic powers of a remarkable kind, that is to say, powers of building up out of very simple bodies compounds of great complexity. The plant possesses namely the power, out of carbonic acid, water, ammonia, and a few mineral salts, of building up such complex bodies as vegetable albumins, starches, sugars and fats, the first being nitrogenous, the second and the third being non-nitrogenous.

When we inquire further into the nature of the processes which go on in the vegetable organism we find that these processes of synthesis or building up are intimately connected with the power which the plant possesses of separating the atoms of certain chemical compounds presented to it, and building up the separated atoms into new combinations. Such a body as starch for instance necessitates on the part

of the plant a separation, a tearing asunder, as it were, of atoms of carbon from atoms of oxygen as they existed in carbonic acid, the carbon being retained by the plant-cell, while the oxygen is in part thrown out of it.

This remarkable power of tearing asunder the atoms existing in the simple bodies which constitute the chief elements of plant food, is however only possessed by the plant in the presence of the rays of sunlight. It is the radiant energy of the sun which, acting through the intermediation of the vegetable cell, tears asunder carbon from oxygen, hydrogen from oxygen; and the energy which has effected the decomposition becomes, as it were, latent in or associated with the separated atoms in the position which they occupy in the newly formed complex organic bodies. All the bodies thus formed, *the proteids*, *the starches*, *the sugars* and *the fats*, are combustible, that is to say under favourable circumstances they may be made to oxidise or burn, and in the process of oxidation or combustion the *potential* energy which was stored in them becomes *actual* or *kinetic*, and takes the form of heat. All these substances may similarly be used as articles of food for animals and be burned within the tissues, and thus furnish the animal with the energy which it requires for the performance of the external work which the individual has to perform, and for the maintenance of the temperature which is so necessary to the life of the body. Some of my hearers may be surprised at the statement that organic constituents contained in the food of the animal body are derived entirely from the vegetable kingdom, and may remark that man partakes of food which in great measure is derived from animals, and not from plants. I would point out to these, however, that the animals which we consume as food, or the milk which is supplied to us by certain of these animals, furnish us with matters derived primarily from the vegetable kingdom, and which have been in some degree modified, and yet substantially stored up for our use by the animal. The sheep and oxen whose flesh we consume are but store-houses containing plant products which these creatures accumulate in

their tissues for our use, so that when we consume the flesh of an ox, though we obtain the proteid which that flesh contains immediately from the animal tissue, it is yet but proteid derived in the first instance from plants. As however the diet fit for the support of animal life must of necessity contain an admixture of the various groups of food constituents to which reference has already been made, it is advisable that we should for a moment or two consider the characters of each group.

Classification of the Organic Constituents of Food.

1. *The proteid or albuminous substances.*—The most essential of all the chemical constituents of the tissues of animals and vegetables are called proteid or albuminous bodies.

The animal organism, for instance, in its earliest stage is represented by a single cell, the ovum, which is a nucleated mass of so called *protoplasm*. This protoplasm, matter endowed with marvellous potentiality, contains as its chief constituent the proteid or albuminous bodies which we are now considering. From this one primary protoplasmic mass all the tissues and organs of the body are derived, and in every case descendants of the original protoplasmic mass form the foundation or, as it were, the sub-stratum of the tissues and organs.

The elements carbon, hydrogen, oxygen, nitrogen and sulphur, which proteids contain, are combined together in proportions which differ but slightly in the case of the several proteids.

The following table indicates approximately the variation in the composition of the animal and vegetable proteids :—

	C.	H.	N.	S.	O.
From .	51·5	6·9	15·2	0·3	20·9
To. .	54·5	7·3	17·0	2·0	23·5

In addition to these constituents, the proteids, however carefully they may have been prepared, usually contain a small quantity of mineral matter, the composition of which varies in different cases, chlorides and phosphates of the alkaline metals being the predominant constituents. These proteids, or as they are often called *albuminous substances*, are abundant in blood, in muscles, in milk, in eggs, and are present in considerable proportions also in such vegetable products as wheaten flour or the leguminous seeds. Certain of these proteids are capable of existing in solution in pure water, others only in water holding small quantities of mineral matters in solution, whilst some are altogether insoluble in water. Even those which are soluble in water may be rendered insoluble by sundry agents. The various albuminous bodies present chemical reactions of which some are common to all members of the group, and others more or less characteristic of individual substances. It will be observed that in these bodies the proportion of nitrogen to carbon is very much higher than the ratio in which the nitrogen thrown off from the animal body stands to the carbon.

2. *Starches and sugars.*—These bodies are often spoken of as belonging to the group carbohydrates, an antiquated term which, whilst it has lost its former meaning, may serve to remind us that these bodies contain hydrogen and oxygen in the proportion in which these elements are contained in water, so that the carbohydrates may, so far as elementary composition is concerned, be considered to be made up of a certain number of atoms of unoxidised carbon, and a certain number of molecules of water. The starches and sugars are present in the largest quantities in the vegetable foods which animals consume, though sugar is contained in considerable quantity in milk. The starches are bodies which are generally introduced into the animal economy in an insoluble condition; they will be studied in detail in a subsequent lecture. The sugars are highly soluble bodies. These carbohydrates are usually found associated with proteid matters in various forms of

vegetable food, though the proportion of the two groups varies remarkably.

Thus in peas we have an instance of a vegetable containing large quantities of proteids in reference to starches, while in rice the starches enormously preponderate.

3. *The fats.*—Both vegetable and animal tissues contain varying proportions of fats. The vegetable oils, milk, butter, the adipose tissue of animals, all contain large quantities of fats. Like the starches and sugars, the fats are non-nitrogenous. They contain less oxygen than would be required to combine with their hydrogen to form water. The number of animal fats which preponderate are three so-called neutral fats, termed stearin, palmitin and olein. The first of these is most abundant in the most solid fats, the third in the most diffluent or softest fats. Each of these constituents, namely, olein, palmitin and stearin, may readily be decomposed into the soluble substance glycerine and into a fatty acid: this may be brought about by subjecting them to the action of steam or by boiling them for a considerable time with alkalies or their carbonates. Thus stearin may be decomposed into stearic acid and glycerine: palmitin into palmitic acid and glycerine, and olein into oleic acid and glycerine. Of the fats it may be remarked that they are not, like the proteids, formed only by the agency of vegetable bodies. The animal economy appears unquestionably to possess the power of decomposing proteids, and obtaining from them fats; and it has also in all probability the power of forming fats out of starches and sugars.

Rationale of a Mixed Diet.

If we now contrast the ultimate chemical composition of proteids, carbohydrates and fats, taking as an example of the proteid group vegetable albumin, of the carbohydrate group starch, and of the fatty group olein, we arrive at the following conclusions:—That the fat contains a much larger proportionate quantity of carbon than either the proteid or the carbohydrate, that its proportionate quantity of

hydrogen is also very much higher, and that the relative amount of oxygen is very much less in fat than in the proteid or the carbohydrate; in this respect the carbohydrate occupies a middle position.

But the most remarkable fact which would be discovered in this comparison would be that the element nitrogen, along with sulphur in smaller proportions, is absent from the starch and the fat, and present only in the proteid group of food-stuffs. As nitrogen is the characteristic and indispensable element in all living matters, the proteid group of food-materials, because it alone contains this element, must be declared to be the essential constituent of all diets. As we survey the tables of elementary composition of the typical constituents of food we gain an insight into the meaning of the instinct which has led man to select a mixed diet, in which proteid, carbohydrate and fatty elements are represented, and in which the two latter preponderate over the former. A man must, as we have pointed out, obtain in his food as much nitrogen as corresponds with that which leaves his body daily in the form of urea, an amount which ordinarily may be set down as about 300 grains. This nitrogen can only be present in bodies belonging to the group of proteids or their immediate derivatives. All diet therefore in order to support life must include proteid or albuminous substances containing at least the above quantity of nitrogen: that is an amount of proteids amounting to about 2000 grains.

But the body requires, besides 300 grains of nitrogen, about 4000 grains of carbon. Were this carbon to be obtained exclusively from proteids, the quantity which would have to be consumed would be enormous; and there would be introduced into the system an amount of nitrogenous material greatly in excess of the requirements.

This would throw an unnecessary amount of work upon various organs of the body, and, as these organs are constituted, would soon lead to disease of them. Instinct however teaches us to mix with the proteid food large quantities of non-nitrogenous food from which the

body may obtain the greater part of the carbon and the hydrogen which correspond to the quantities of these elements which are oxidised.

Calorimetrical value of foods.

Before giving instances of diets which contain the various groups of food constituents in proper proportions to support the life of man, I may add some additional theoretical considerations in reference to the value of the different groups of food constituents as givers of energy to the body. By completely oxidising the same weight of different food constituents in instruments called *calorimeters*, in which the heat of the burned body is employed in heating a known volume of water, or in melting ice, the total amount of energy which each substance is capable of yielding on oxidation may be determined and may be expressed in so-called *heat units*. The heat units employed in such determinations vary, though one may be readily converted into the other; that which is most frequently employed by scientific men is called the *gramme unit* or *calorie*, which may be defined as the amount of heat required to raise the temperature of one gramme of water one degree Centigrade. The table to which I now draw your attention exhibits the number of heat units evolved by the complete combustion of an equal quantity (namely one gramme or 15·432 English grains) of various substances.

Heat evolved during the complete combustion of one gramme of the following substances :—

Albumen	4998
Butter (in its ordinary moist condition)	7264
Fat of ox	9069
Arrowroot	3912
Cane sugar	3348
Urea	2206

These numbers allow us to see at a glance that of all food-stuffs the fatty bodies are those which contain the largest store of available energy. Next to them come the proteids, and lastly the carbohydrates. It would be a

mistake, however, to read such a table absolutely and without reservation. In the calorimeter the substances submitted to experiment are oxidised as completely as it is possible for them to be, and the numbers in the table express the utmost possible yield of energy, supposing oxidation to be carried to its extreme limit. Now the body has not the power of bringing about this perfect oxidation of all substances: some substances are doubtless burnt up into the most stable and ultimate form of CO_2 and H_2O. But such complete oxidation is not possible in the case of proteids, which in all probability are capable of yielding in the body no more than 4263 calories per gramme weight instead of 4998 as stated in the table.

As the object of taking food is twofold—viz. (1) to repair certain losses which the organs and tissues (proteid for the main part) are continually sustaining; and (2) to furnish the body with a sufficient quantity of potential energy—it is obvious that when the body has obtained as much proteid food, together with water and mineral constituents, as will serve to make up the waste of these constituents, it is at liberty to derive from fats and carbohydrates the greater part of the energy it still stands in need of: especially as the oxidation of these latter bodies is very readily accomplished without entailing the excessive labour in certain organs which the combustion of proteid matters would do.

Constitution of an 'Adequate' Diet.

We may now consider an estimate made by the German physiologist Ranke of the various quantities of proteids, fats and carbohydrates which, when present in a digestible diet, are sufficient to support the life of man. According to Ranke a sufficient diet should contain

about 1543 grains of proteids,
" 1543 " " fats,
and 3703 " " carbohydrates.

The amount of energy associated with each of those

groups of food constituents is shown in the table which I now bring before your notice.

1543 grains of albumin	give	426,300	calories
1543 " " fat	"	906,900	"
3703 " " starch	"	938,880	"
Total		2,272,080	

We have here the amount of various food constituents supplying the body with matter and energy in quantity sufficient, according to Ranke, to make up for the losses under both heads. This estimate is, however, rather too low a one. We are inclined to place more reliance upon the estimates of Forster and Voit, according to whom the following quantities of the chief organic food constituents are required by an average man.

Albumin	118	grammes equal to	1820 grains
Fats	88·4	" " "	1364 "
Carbohydrates	392·3	" " "	6053 "

The quantity of nitrogen and carbon in the above diet is the following :—

Nitrogen	18·3	grammes equal to	282·40 grains
Carbon	328	" " "	5061 "

The value of a diet containing this amount of the various constituents in energy is as follows :—

118 grammes of albumin	give	503,034	calories
88·4 " " fat	"	801,699	"
392·3 " " carbohydrates	"	1,534,600	"
Total		2,839,333	calories.

It may interest you to know how much of various articles of food must be consumed in order to supply the organism with the quantity of carbon and of nitrogen which the estimate of Forster and Voit demands. I draw your attention to a table in which on the left hand we have the quantities of various articles of food which contain 18·3 grammes of nitrogen and on the right hand the quantities

of the same articles of food which contain 328 grammes of carbon.

18·3 grammes of nitrogen =			328 grammes of carbon =		
Cheese . .	272	grammes	Bacon . .	450	grammes
Lean meat .	538	,,	Wheaten flour	824	,,
Wheaten flour	796	,,	Rice . . .	896	,,
Eggs (18) .	905	,,	Cheese . .	1,160	,,
Black bread .	989	,,	Black bread	1,346	,,
Rice . . .	1,868	,,	Eggs (43) .	2,231	,,
Milk . . .	2,905	,,	Lean meat .	2,620	,,
Potatoes . .	4,575	,,	Potatoes. .	3,124	,,
Bacon . .	4,796	,,	Milk . . .	4,652	,,
Beer . . .	17,000	,,	Beer . . .	13,160	,,

This useful and suggestive table indicates to us how very limited are the substances which by themselves will supply the body with the proper quantities which it requires of nitrogen and of carbon, and the same remark applies to the energy which it yields. Thus whilst 538 grammes of meat are sufficient to supply all the proteid which the body requires, if meat alone composed the diet of an animal there would be needed as much as 2620 grammes to supply all the carbon required; but no man could day after day consume such an enormous quantity of meat. Even milk, which contains all the various groups of food constituents, is not adapted to supply all the elements of a perfect diet in their proper proportions for an adult animal; for whilst all the nitrogen which its body needs could be afforded by the consumption of 2905 grammes of milk, in order that the amount of carbon needed should be obtained, the milk consumed would have to reach the enormous amount of 4652 grammes, in other words over ten English pounds.

It will be observed that there is only one article of diet in each of these tables, namely black bread, which contains nitrogen and carbon in such proportions that a moderate weight of it is able to supply the wants of the economy for both these elements. From 1300 to 1400 grammes of black bread constitute, therefore, almost a standard diet, and I may mention that upon this diet large numbers of

men are able to live in health and to accomplish great labours. In some of the departments in the south of France black bread constitutes almost the only food of a vigorous and laborious population.

The Principal Food-stuffs examined.

Although food will be considered in detail in a handbook specially devoted to the subject, it will be advisable that we should here make some further remarks upon the chief articles of food which enter into the composition of our dietary. We may do so under the following heads.

1. Meat.
2. Eggs.
3. Milk.
4. Vegetable foods.
5. Water and mineral salts.
6. Infusion of tea, coffee and cocoa.
7. Wines, beer and spirits.

1. *Meat.*—Meat is composed of the flesh or muscular tissue of herbivorous animals. In addition to muscular fibres it contains a certain amount of connective tissue with imbedded fat, the latter varying in amount between 4 and 5 per cent. The muscular substance which constitutes meat proper contains about one fourth of its weight of water-free solids, that is to say about 25 per cent. and of this 18 per cent. consists of albuminous substances proper, and about 2 per cent. of gelatigenous substances. When meat is chopped up and treated with cold water, or still better with water heated to about 55 or 60 degrees Centigrade, the water extracts from it firstly proteids, which are almost entirely coagulated on subsequently boiling the liquid; secondly a mixture of nitrogenous so-called extractive matters, of which the chief is a body called creatine; thirdly salts, of which those of potassium are much the most abundant. When meat is treated for a long time with boiling water or water approaching the boiling temperature, in addition to the whole of the salts and extractive matters, the solution contains no inconsiderable

quantity of gelatine, formed by the action of water upon the interstitial connective tissue of the meat. Beef-tea is but a solution of the saline and extractive matters of beef; Liebig's extract is but an evaporated beef-tea containing in a small volume the extractive matters and the salts of a large quantity of beef, and in virtue of this possesses medicinal and dietetic properties not to be despised; yet if considered as a food, it in no sense represents the meat which has yielded it, since it has lost the essential albuminous element.

When meat is boiled or roasted the exterior should be rapidly heated, so that the proteids on the surface may at once be coagulated and form a case to prevent the escape of the interior juices. The subsequent cooking may then be carried on at a low temperature—say 160° F.—and with slowness, so as to cause the fibres to set loosely without shrinking or hardening.

The object of the various methods of cooking meat are, if we leave out of consideration the altogether secondary object of rendering it more savoury and appetising, to increase its digestibility and to destroy parasites and the germs of both vegetable and mineral organisms whose subsequent development might be fraught with danger to life.

2. *Eggs.*—An average hen's egg is said to weigh about 1·75 ounce, of which the shell forms one tenth. Eggs contain about 73 per cent. of water, about 15 of albumin, and 12 of fat containing a body called lecithin. The fat and lecithin are mainly contained in the yolk, whilst the greater part of the albumin is contained in the white of the egg. When eggs are boiled the albuminous constituents are, in the case of soft-boiled eggs, heated and only partially coagulated: in the case of hard-boiled eggs, the albumin of the white of the egg and the so-called vitellin of the yolk are coagulated so as to convert them into solid masses.

3. *Milk.*—This liquid, which is the secretion of the mammary gland, constitutes for the earlier part of life, a typical diet, containing representatives of the different

groups of food constituents, although not in the proportions in which these are most useful for an healthy adult body. Milk has a specific gravity which may be as a rule stated at between 1030 and 1033. It contains about 12 per cent. of solids, including about 3 per cent. of fats in the form of butter, about 3 per cent. of casein, about 4 or 5 per cent. of sugar, and about 0·02 per cent. of salts. The sugar which is contained in milk, and which is sometimes called lactose, has a composition $C_6 H_{12} O_6$. *Buttermilk* consists of milk from which the fat has been removed, and therefore contains chiefly sugar, casein, and salts. *Whey* consists of milk from which the casein has been precipitated by the action of rennet. *Cheese* consists of the casein of milk precipitated by rennet: it contains also very much of the fatty matter of the original milk.

4. *Vegetable foods.*—The most important of the articles of vegetable food is *wheaten flour*, which contains about 13 per cent. of a mixture of proteids constituting the so-called *gluten*, and about 73 per cent. of *starch*. Bread is made by mixing wheat-flour with water and salt, so as to form dough, to which is afterwards added yeast. The starch is converted into various so-called dextrins, and then into sugars, which then undergo alcoholic fermentation under the influence of the yeast plant. This leads to the evolution of carbon dioxide, which causes the dough to "rise." When the dough, after being divided into masses of size suitable to form loaves, is heated in the oven to the temperature of 150 or 200 degrees Centigrade, the carbon dioxide and alcohol generated in the process of fermentation are expelled, and in their escape cause the dough to assume a spongy texture and to become "light." Barley and oatmeal, although serviceable as foods, and containing considerable quantities of proteids, do not yield a dough which admits of being made into bread. The value of *oatmeal* as an article of diet is however very well known and recognised by all.

Peas and *beans* afford examples of vegetable foods which are remarkably rich in proteids, containing about 25 per

cent. of legumin, which is closely allied to the casein of milk. They also contain about 38 per cent. of starch.

Potatoes contain on an average about 75 per cent. of water. The solid matter consists mainly of starch with a small quantity of proteid matter and mineral matters which are specially rich in potassium salts.

Fruits and *succulent vegetables* are of value owing to the sugar, the organic acids, and the salts which they contain.

5. *Water and mineral salts.*—The body of man contains more than one half its weight of water, and, as I have told you, very large quantities of water are daily being excreted from the body. Want of water makes itself more imperatively felt, and leads more rapidly to death, than even want of solid food. As, however, the food of man—I refer to the solid food—all contains large quantities of water, life may be supported when but little actual liquid is consumed. The quantity of water, pure or mixed with organic matters, such as alcohol, or coffee and tea-extractives, which is sufficient for a man under ordinary circumstances, may be stated at from one to three pints, though the quantity needed is remarkably influenced by certain circumstances and particularly by the temperature to which the body is subjected.

The mineral matters required daily by man are contained in the various articles of food which he consumes. Instinct, however, leads man to mix with his food considerable quantities of sodium chloride or common salt.

6. *Infusion of tea, coffee and cocoa.*—Tea leaves and coffee berries contain rather less than 2 per cent. of a neutral nitrogenous principle termed *thein* or *caffein*. Tea leaves contain, in addition, large quantities of tannic acid and other extractive matters, amongst which are to be mentioned indefinite and imperfectly known volatile principles to which the infusion owes much of its aroma and taste. Coffee berries contain, in addition to caffein, large quantities of insoluble matters, also sugar, dextrin, and aromatic constituents, besides considerable quantities of fatty bodies.

7. *Wines, beers, and spirits.*—The various kinds of wine

consist of the juice of the grape which has undergone alcoholic fermentation. Wine consists of water holding in solution alcohol, with sugar, vegetable acids and their salts, besides colouring matters, and traces of proteids. The quantity of alcohol varies from 6 to 25 per cent.; wines which contain as much as this having usually received a quantity of alcohol over and above that produced by alcoholic fermentation of the sugar of the grape. The peculiar flavour or bouquet of wines depends in great measure upon certain compound ethers which they contain.

Beer is obtained from the infusion of malt, that is, of barley which has been allowed to germinate, and in which the starch has been converted into dextrins and sugar. The infusion of malt is fermented by the addition of yeast, which converts the sugar into alcohol. The bitter flavour of beer is imparted to it by the addition of hops or other bitter substitute. The amount of alcohol in beer varies between 2 and 10 or 12 per cent. It also contains a greater or less quantity of CO_2, upon which its properties to a certain extent depend.

Spirits.—The various forms of spirit consist of water containing from 50 to 60 per cent. of alcohol. They are all obtained by first inducing alcoholic fermentation in a saccharine liquid which is thereafter subjected to distillation.

Effects following Deficient and Excessive Diet.

Before concluding this lecture, which is barely introductory to the subject of digestion, I wish to draw your attention to the effects of an insufficient and an excessive diet. Firstly, when food is entirely cut off from the body, as its losses continue, it loses weight, and the healthy and pleasurable appetite for food and drink makes place for the sufferings of hunger and thirst. The strength of the body diminishes, so that at last all exertion becomes impossible, whilst the temperature becomes much reduced.

An insufficient diet leads to results which resemble more or less closely those which attend an absolute deprivation

of food. The wasting of the body, loss of weight and lack of ability for work, are amongst the most prominent phenomena. The proclivity to particular disorders of nutrition, as for example to scurvy, no less than the tendency to become affected by zymotic diseases, has been noticed in cases where individuals and populations have been subject to the influence of deficient food. The epidemics of typhus and of relapsing fevers which have followed famine in Ireland, may serve to illustrate the fact upon which I am dwelling.

Secondly. In the case of an excessive diet various results may follow. When the amount of food taken is in excess of the wants of the economy and yet not so much as to be beyond the capacity of the body to digest it, it is observed as a rule that the weight of the body is increased, and this is due in great measure to a deposition of fat. The rapidity with which the increase in weight occurs depends however upon a large number of circumstances, as for instance on the predisposition of the body to accumulate fat, and on the amount of work done by it. In many cases, when the diet continues for long periods of time in excess of the proper demands of the system for matter and energy, there are induced functional disorders of the organs of digestion, and of the organs which are chiefly concerned in dealing with the products of digestion, as for example the liver; or there may be induced such a disorder of nutrition as constitutes the disease gout, though in the production of this complaint alcohol is an adjuvant and almost necessary factor.

LECTURE II.

GENERAL SKETCH OF THE DIGESTIVE APPARATUS—THE ALIMENTARY JUICES—MASTICATION AND THE ORGANS CONCERNED IN IT.

In my first lecture I have explained to you that a supply of Food and of Oxygen gas are absolutely essential to an animal body, in order that it should manifest the phenomena which are essential to Life, for all these phenomena are associated with a dissipation from the body of Energy, which can only be obtained by a transformation, re-arrangement and elimination of certain of the matters of the body. In former times, before clear ideas had been formed as to the sources, relations and transformations of Energy, it was not absurd to speculate on the possibility of discovering agents which, whilst innocuous to life, should diminish indefinitely the waste of the body. We now know such speculations to be absurd, inasmuch as the act of living implies transformations of energy associated with transformations of matter, i.e. continual losses which have to be made up.

The needs of the animal body for matter to take the place of that which is passing away from it are made known to it by certain sensations. The need for pure air containing the oxygen gas which the body requires in such large quantities to oxidize or burn its organic constituents, is under normal circumstances imperceptible to us; so soon, however, as the supply of oxygen falls below the wants of the system we have a train of symptoms, ushered in by shortness of breath, exaggerated movements of respiration, and anxiety for fresh air, which not only make the organism acquainted with the special want, but likewise in many cases at once remedy the deficiency which exists.

Hunger and Thirst.

The needs of the body for solid and especially for organic food, and for water, make themselves felt by the peculiar sensations of *hunger* and *thirst*.

Hunger is a peculiarly indefinite sensation of craving or want, which is referred to the stomach, but with which is often combined, always indeed in its most pronounced stages, a general feeling of weakness or faintness. The earliest stages are unattended with suffering, and, leading the animal to wish and seek for food, are characterized as "appetite for food." Hunger is normally appeased by the introduction of solid or semi-solid nutriment into the stomach, and it is probable that the almost immediate alleviation of the sensation under these circumstances is in part due to a local influence, perhaps connected with a free secretion of gastric juice. Essentially, however, the sensation of hunger is a mere local expression of a general want, and this local expression ceases when the want is satisfied, even though only liquid and no solid food be introduced into the stomach, or even though no food be introduced into the stomach, but the needs of the economy are met by the introduction of food through other channels, as, for example, when food which admits of being readily absorbed is injected into the large intestine.

Thirst is a peculiar sensation of dryness and heat localized in the tongue and throat. Although thirst may be artificially produced by drying, as by the passage of a current of air, the mucous membrane of the above parts, it normally depends upon an impoverishment of the system in water. And when this impoverishment ceases, in whichever way this be effected, the sensation likewise ceases. The injection of water into the blood, the stomach, or large intestine, appeases thirst, though no fluid is brought in contact with the part to which the sensation is referred.

Nature of the Processes of Digestion.

The sensations, the causes of which I have attempted to analyse, lead us, or, when urgent, compel us to take food and drink into the mouth. Once in the mouth, the entrance of the alimentary canal, the food is subjected to the first of a series of processes, whose assemblage constitutes the Function of Digestion. Digestion may be defined as *the assemblage of processes, mechanical and chemical, whereby the constituents of food are rendered soluble and converted into substances which are capable of being absorbed, and afterwards assimilated.* To the precise meaning of these terms, and to the processes concerned in absorption and assimilation, I shall direct your attention in the last of this series of lectures.

A PRELIMINARY GENERAL SKETCH OF THE ORGANS OF DIGESTION IN RELATION TO THEIR FUNCTION.

I wish at the very outset to point out very clearly to you that the food which we introduce into the alimentary canal is, strictly speaking, outside the confines of the body ; as much, indeed as the fly grasped in the leaves of Venus's fly-trap—the insectivorous Dionea—is outside of the plant which is to digest it.

The mechanical and chemical processes to which the food is subjected in the mouth, stomach and intestines, are processes which have their seat and conditions outside of the body which it is destined to nourish, though unquestionary the body is no passive agent, and innumerable glands have to come into action in order to supply chemical agents able to dissolve and render *assimilable* those constituents of food which are capable of being absorbed *into* the organism, and forming, as it were, part and parcel of its substance.

The processes to which the food is subjected, though manifold, are divisible into two great groups. (1) Chemical. The food must be subjected to the action of certain juices,

which dissolve insoluble alimentary matters, and modify these, besides acting upon certain of the soluble alimentary constituents in the one case, and in the other the end being to produce bodies which shall not only be *soluble*, but likewise *diffusible*.

(2) Mechanical. The food must be first broken up and crushed, more or less completely, and afterwards mechanically mixed with the digestive juices, and the mixture propelled slowly from beginning to end of the alimentary canal.

In accordance with this double set of processes—the chemical and the mechanical—which go on in the alimentary canal, it presents the form of a complex and in some regions modified tube, possessed of two openings, where it is continuous with the general surface of the body—a tube, however, which is, as it were composed of two distinct but intercalated tubes. (1) An internal tube of *mucous* membrane, and (2), investing this closely and connected with it, an external muscular tube.

I point to a rough diagram (see Fig 1) which exhibits the general arrangement of the alimentary canal, and I wish now to direct your attention to some general anatomical facts in relation to it, reserving, however, a minuter study of some of its component organs to subsequent lectures, in which a closer acquaintance with structure will be needed, in order that we may study their functions with accuracy.

You observe that the muscular membranous alimentary canal is not regularly tubular throughout. At the beginning it forms the irregular cavity of the *mouth* (M), which contains the *tongue* and the masticatory *teeth*. Thence it passes through the *fauces*, and beneath the pendulous *soft palate* and *uvula*, into the *pharynx* (Ph). Afterwards it proceeds as a regular tube, the *œsophagus*, (Œ) or *gullet*, which dilates at the cardiac orifice into the *stomach* (S), at the further, or *pyloric*, end of which the tube resumes its narrow uniform calibre, constituting at this part the small intestine which is arbitrarily divided into the *duodenum* (D), *jejunum* (J), and *ileum* (I), of which,

Fig. 1.

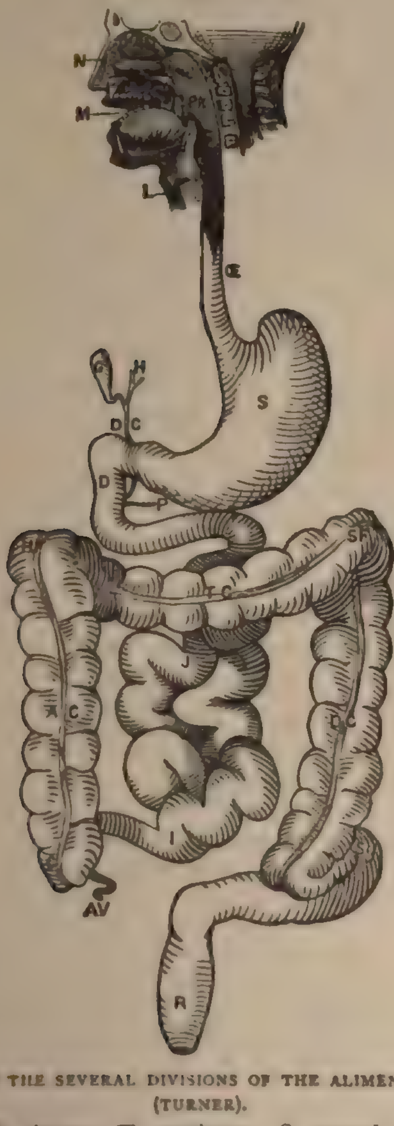


DIAGRAM OF THE SEVERAL DIVISIONS OF THE ALIMENTARY CANAL (TURNER).

M. mouth; Ph. pharynx; Œ. œsophagus; S. stomach; D. duodenum; J. jejunum; I. ileum; AV. appendix vermiformis; AC. ascending colon; HF. hepatic flexure; TC. transverse colon; SF. splenic flexure; DC. descending colon; Sg. sigmoid fluxure; R. rectum; L. larynx; E. Eustachian tube; G. gall-bladder; H. hepatic duct; DC. common bile duct; P. pancreatic duct.

in man, the duodenum occupies a length of twelve fingers, the ileum the lower three-fifths, and the jejunum the intermediate portion of the total length of 20 feet. The small intestine diminishes somewhat in calibre from duodenum to ileum, and at the lower end of the latter the small opens suddenly into the much wider larger intestine: though not at the very commencement of this, which is a cul-de-sac, the *caput cæcum coli*, but at a point a little removed from this.

The margins of the aperture by which the small gut opens into the large, project into the latter in such a manner that while they readily permit the passage of matters from small into large intestine, any backward movement of the contents of the large intestine would have the effect of compressing the lips of the opening and closing it; this arrangement constitutes the so-called *ilio-cæcal valve.* Connected with the *caput cæcum coli* is a small diverticulum like a narrow glove finger, called the *vermiform* appendage (A V). The first and greater part of the large intestine is known as the *colon*, the last as the *rectum* (R). The colon is subdivided into ascending colon (A C), transverse colon (T C), and descending colon (D C), the bend made by the transverse in passing into the descending colon receiving the name of the *sigmoid flexure.* (S) The lower orifice of the rectum is the anus. The total length of the large intestine is from five to six feet.

Both muscular and membranous (mucous) tubes are continuous from mouth to anus, and at these, the superior and inferior orifices, the *mucous membrane*, which constitutes what we have hitherto termed the membranous tube, is continuous with the skin which covers the general surface of the body. This mucous membrane is covered throughout at its free surface by a layer or layers of cells, the so-called *epithelium*, and gives lodgment to glands, whose characters differ in different parts of the tube in accordance with the function of the part. Below the epithelium is a connective tissue analogous to the true skin, which in parts has the character of ordinary fibro-areolar tissue, but in all parts from the stomach downwards has the character of so-called *adenoid connective tissue*, as it is found in the follicles of lymphatic glands. Its meshes support a rich supply of fine blood-vessels, lymphatic vessels, and doubtless also of delicate nervous filaments. Besides these elements there are found numerous small

bundles, or in parts even sheets, of ***involuntary muscular fibres***, which probably give to the mucous membrane the power of limited self-contraction, of such a nature as to further the flux and reflux of fluids in the myriad lymphatic vessels of the part, and perhaps to influence in no small degree the outpouring of the secretion of certain of the glands. To the fairly continuous tract or sheet of involuntary muscle which lies at the base or deepest part of the mucous membrane the term of (tunica) *muscularis mucosæ* is applied.

In addition to the glands which lie embedded in and open upon the surface of the mucous membrane of the alimentary canal, others of larger size and not in immediate relation with its walls communicate with the interior of the tube by ducts which open into it, and which pour into it their secretion; such glands are the salivary glands, the pancreas, and the liver.

The muscular tube in the greater part of its extent consists of two layers of involuntary, non-striated, pale, muscular fibres—an inner whose fibres encircle the tube, and an outer whose fibres run parallel to the long axis of the tube. But this is not the arrangement of every part. In the stomach there is an apparent rather than a real exception, where some layers of fibres of the circular coat course over the dilated walls of the alimentary tube in an oblique direction, giving rise to an oblique layer. In the œsophagus or gullet, besides the typical, circular, and longitudinal layers, there is at the upper part a second longitudinal layer which takes up a position internal to—that is, nearer—the mucous membrane than the circular layers. In the upper part of the gullet also the muscular fibres are not unstriped, but, although certainly involuntary, are striated like voluntary muscles.

In the mouth the muscular tube is most irregular and most defective, for the mucosa is in parts directly applied to the bony boundaries, as over the hard palate and gums; in another part it invests the muscular prominence of the tongue; whilst in other regions it lies upon the constrictors of the pharynx and the inner aspect of certain other muscles, as those of the cheeks, lips, and floor of the mouth. The membranous tube is united to the muscular tube by a loose layer of connective tissue containing many blood-vessels and lymphatic vessels and nerves for the supply of the mucosa; it is often called the *submucosa*.

The mucous membrane is the seat of various secreting glands, which lie embedded in its substance and open upon its surface,—simple or branched tubular recesses running through the depth of the layer, lined by epithelium, continuous with, though not always resembling, that of the surface, and opening at the surface by minute pores. In the mouth, pharynx, and œsophagus those form the *acinous* or *racemose* glands, which, according to certain subordinate features which they present, and also according to certain of the characters of the fluids which [illegible]crete, are separated into *mucous* and *serous* glands.

In the stomach they are represented by the simple or branched tubular gastric glands. In the duodenum we find them as simple tubular deep sockets, the crypts or glands of Lieberkühn, and also as the compound, acinous glands of Brunner, which dip below the level of the mucosa and lie in the submucosa. In the jejunum, ileum, and large intestine they form again the crypts or follicles of Lieberkuhn.

The membranous tube is not everywhere exactly concentric and conterminous with the muscular tube. In the mouth and pharynx this is so almost entirely, but at the gullet the muscular tube so tightly encloses the membranous that the latter is forced into longitudinal plications to find room for itself. In the stomach the membranous layer is raised into ridges or *rugæ*, which intersect and give the surface a honeycomb-like aspect. In the upper part of the small intestine the membranous tube is raised into deep annular or, more correctly, crescentic folds, running across the direction of the gut like incomplete diaphragms, or a series of membranous ledges; these are the *valvulæ conniventes*. In the colon the two tubes are so disposed as to form a regular series of saccules or pouches, greatly enlarging the capacity of the gut. All these foldings greatly enlarge the superficies of the membranous tube. A further enlargement is effected in the small intestine in an exceedingly interesting fashion; the surface of the mucosa is thickly studded with innumerable, fine, short projections resembling the pile of velvet. These are invested by surface epithelium, and amongst them, at their feet, open the before-mentioned *crypts of Lieberkühn*. They are the so-called *villi*. Each contains a lymphatic vessel, blood-vessels, and involuntary muscular fibres, all supported by adenoid connective tissue like that of the mucosa below; the lymphatic is in the axis of the villus, the muscles form the next layer, and the blood-vessels lie immediately beneath the epithelium. When the muscular layer of the villus contracts it must of necessity compress the lymph vessel, whilst causing no impediment to the flow of blood.

We have described the mucous membrane of the stomach and intestines as containing a framework of adenoid reticular tissue like the tissue of lymphatic follicles. It is, indeed, identical with this,—a network of branched cells with oval nuclei, and the meshes of which are crowded with lymph corpuscles with round nuclei. At certain points in the intestines the adenoid tissue of the mucosa presents local nodular enlargements; the mucosa at these points becomes so much thicker that it swells up at the free surface beneath the epithelium into rounded eminences about as large as millet-seeds or the heads of small pins; and at the under surface of the mucosa it dips into the submucous tissue in a similar manner. At the base of this nodule of adenoid tissue in the submucosa there is usually a network of wide, thin-walled, lymphatic vessels. Many of these rounded masses are scattered irregularly over small and large intestine as the *solitary follicles* or *glands*, but at the lower end of the ileum they form little colonies, often covering an area an inch or more in length, and they are situated at

that part of the intestine which is remote from the attachment of the mesentery. They then constitute the so-called *Peyer's patches.*

Nodular adenoid masses are, however, not limited to the adenoid mucosa of the intestines. They are occasionally, though rarely, found in the stomach; they exist beneath the mucous membrane of the tongue, and a colony of them forms the mass of the *tonsil* on each side,—that almond-shaped body situated between the posterior and anterior pillars of the fauces.

The intrinsic nerves of the alimentary tube consist of two systems of nervous networks with ganglion cells lying at the nodes; one is found in the submucous layer ('Plexus of Meissner'), the other lies between the longitudinal and circular muscles ('Plexus of Auerbach.')

The whole of the intestines, and the stomach as well, are sustained in the abdominal cavity by sheets of delicate membrane, formed by folds of peritoneum, and called, in the case of the intestinal portion of the tube, the *mesentery.* Between the layers of the mesentery run the vessels and nerves for the supply of the bowel. In addition to blood-vessels there are numerous thin-walled lymphatic vessels called *lacteals*, which are fed by the rich network of lymphatic vessels of the mucosa and submucosa, and which run in the mesentery to the back of the abdominal cavity. Here they are collected into a large lymphatic reservoir, the *receptaculum chyli*, from which a duct, the *thoracic duct*, proceeds along the side of the vertebral column to open into the venous system at the junction of the subclavan and jugular veins on the left side of the neck. The lacteal and lymphatic vessels, whose course has been briefly sketched, are interrupted at many points by the presence of lymphatic glands. These may be simply regarded as labyrinthine systems of vessels into which the simple *afferent* lymphatic or lacteal vessels open, and each of which is surrounded and penetrated by adenoid connective tissue, like that of the intestinal mucosa. The lacteal vessels after food are filled with a milky fluid, the *chyle.* They were discovered by Aselli in the year 1662.

It must not be thought that the glands of the mucous membrane of the alimentary canal are alone engaged in the preparation of the solvent digestive fluids. Other organs lying away from the alimentary canal pour their secretions into it by ducts at various points. In the neighbourhood of the mouth there are three pairs of *salivary glands;* the *parotid* glands, lying outside the cheek over the lower jaw, just in front of the meatus of the ear. The ducts of the pair course along the cheeks and pierce them opposite the second upper molar tooth on each side. These are the two ducts of Stenson. A second pair, the *sub-maxillary*, lies beneath the ramus of the lower jaw and beneath the floor of the mouth; their ducts run forward to open beneath the tongue: these are the ducts of *Wharton.* The third pair, the *sublingual*, lies on the floor of the mouth, beneath the mucous membrane anterior to the openings of the ducts of Wharton. The ducts of these glands are numerous, and open by many apertures on the floor of the

mouth, some opening into the ducts of Wharton. These constitute the ducts of Rivini.

About three or four inches below the pylorus the ducts of two large glands open into the small intestine by a common orifice; these are the pancreatic duct, from the pancreas on the left, and the common bile duct from the liver on the right.

The Alimentary Juices the products of Secreting Glands.

Having made a general survey of the anatomical arrangements of the alimentary canal, before commencing a detailed study of the digestive processes, I wish to draw your attention to certain important general facts connected with the alimentary juices.

I have already told you that the processes of digestion depend essentially upon these juices, which require for their proper action certain physical conditions, and are aided by certain mechanical operations.

These juices, which we shall study in detail under the several titles of saliva, gastric juice, pancreatic juice, bile, and intestinal juice, are all the products of organs termed *secreting glands*, because they are engaged in separating or *secreting*, at the expense of matters derived from the blood, the liquids which form their characteristic *secretion*. The secreting glands of the alimentary canal may be considered to have been formed by an involution of the mucous membrane which lines it, which may either be simple, test-tube like, as in the so-called glands of Lieberkühn, or exceedingly complex as in the salivary glands or the pancreas. These glands have in some cases distinct ducts or passages which establish a communication between the inner secreting recesses and the alimentary canal, but in all cases they contain, as essential elements, cells of *secreting epithelium*—their so-called *secreting cells*—whose function it is to form the matter of the secretion. All glands are abundantly supplied with blood-vessels, and a like meshwork of capillaries is in close proximity to the microscopic secreting cells; there are, in addition, invariably nerve fibres supplying the gland, though it cannot be said

that the exact connection of fibres with gland cells has yet been traced.

The secreting cells do not draw their nutriment *directly* from the blood, but from the liquid—the lymph—which has transuded from the minutest blood-vessels, *the capillaries*, and which bathes the anatomical elements of all tissues and organs; from this transuded liquid the gland cells obtain both oxygen and liquid and solid matters, and to it they contribute certain products of waste which subsequently make their way into the blood, and are thence got rid of through the intermediation of such excretory organs as the lungs, the kidneys and the skin.

The digestive juices are all of them liquids which contain very much water; in this respect the saliva may be taken as an example, for it rarely contains more than four or five parts per thousand of solids.

The first idea which was formed of the process of secretion was that it resembled closely, if it was not actually identical with, a process of straining or filtration, and the properties possessed by the liquid products of various secreting glands were supposed to depend upon the different characters of their filtering arrangements.

It was afterwards supposed that secretion was more allied to the processes of *osmosis* and *diffusion*, by which movements of liquids and a separation of the solid constituents which they contain may be effected through the agency of thin membranous septa.

These purely physical explanations have, however, been disproved, and I have to tell you that, although influenced by certain of the circumstances which affect filtration, and though doubtless also thus connected with osmotic and diffusion phenomena, *secretion* essentially depends upon the activity of the living anatomical units of the glands, the gland cells. The matter of these cells—their *protoplasm*—possesses as an inherent property the power of abstracting certain matters from the lymph and leaving others, and more than that, of actually manufacturing at the expense of certain of the matters of the lymph, new bodies,

which give special characters to the secretions of particular glands.

During life the activity of these gland cells appears to be influenced both by changes in the blood supply of the whole gland, which are brought about through the agency of nerves distributed to their blood vessels, and by a direct action exerted upon the gland cells by certain nerve fibres which are able to bring about changes in the processes of the cell even independently of changes in the blood supply, even indeed (for a limited period), in the absence of any blood supply.

These alimentary juices which are most active in digestion, particularly the gastric juice, and the pancreatic juice, owe their activity, as we shall see, to the presence in them of certain bodies which have been classed amongst *ferments*, though they differ in many important particulars from the most characteristic ferments.

By the term ferment we usually designate bodies which, even in minute proportions, possess the power of bringing about in particular substances with which they are brought into relation, and under favourable circumstances, chemical changes of great magnitude. The most characteristic ferments are the so-called *organised* or *formed ferments*, of which yeast affords us an admirable example. The action is here necessarily linked with the life of the yeast cell, and it is only so long as the cell is intact and living that it can bring about the characteristic alcoholic fermentation of sugar.

Anything which destroys the organism with which the ferment action of a true ferment is linked, renders it inert; this ferment action cannot therefore be abstracted from the organic form by solvents.

But the term *ferment* has been applied to other bodies which doubtless are definite chemical proximate principles (though as yet we have not succeeded in separating one in a state of such purity as to warrant our stating its precise chemical relations), which are the products of the activity of certain living cells, but which having been once formed

are no longer dependent upon the life of the cell, and may indeed be extracted from it by appropriate solvents, of which glycerine is the most generally available and the best example.

The ferments of the second class are often termed unformed or unorganised ferments. They resemble the organised ferments in their origin in living cells, and in the power which they possess of bringing about chemical changes on a very large scale. But they differ in many other respects, especially in this, that they do not develop or increase whilst their action is being exerted. It is ferments of this class which are present in the alimentary canal. It has been suggested by Kühne that the term *Enzymes* should be applied to the unformed ferments of the animal body.

The living gland cells of certain of the glands of the alimentary canal appear in the first instance to manufacture bodies which are, as it were, antecedents of the ferments or enzymes, to which the generic term of *Zymogens* has been given. These zymogens appear under various conditions to liberate the active and fully formed enzymes.

MASTICATION.

We shall commence the study of the digestive process by an examination of the process of mastication, by which the food is reduced in the mouth to so minute a state of division as enables the nutritive juices which come in contact with it to act with advantage. We cannot obviously understand the process of mastication unless we know something of the structure and mode of arrangement of the teeth, which are the organs specially concerned in it, of their relation to the maxillary bones, or jaws, in which they are implanted, and of the principal muscles which act upon the jaws.

Structure and arrangement of the Teeth.

Nearly all mammals have teeth forming the essential part of the masticatory apparatus, and in a majority of

mammals, as in man, the teeth are not all of one shape, but present distinctive peculiarities, which are related to the functions which they have to perform. In most, though not in all mammals, we observe, moreover, that we

Fig. 2.

THE SUPERIOR AND INFERIOR MAXILLARY BONES (QUAIN'S ANATOMY).

A. Superior Maxillary Bone of the right side from the outside.
B. The same bone seen from the inside.
C. The Inferior Maxillary Bone seen from the right side and above.

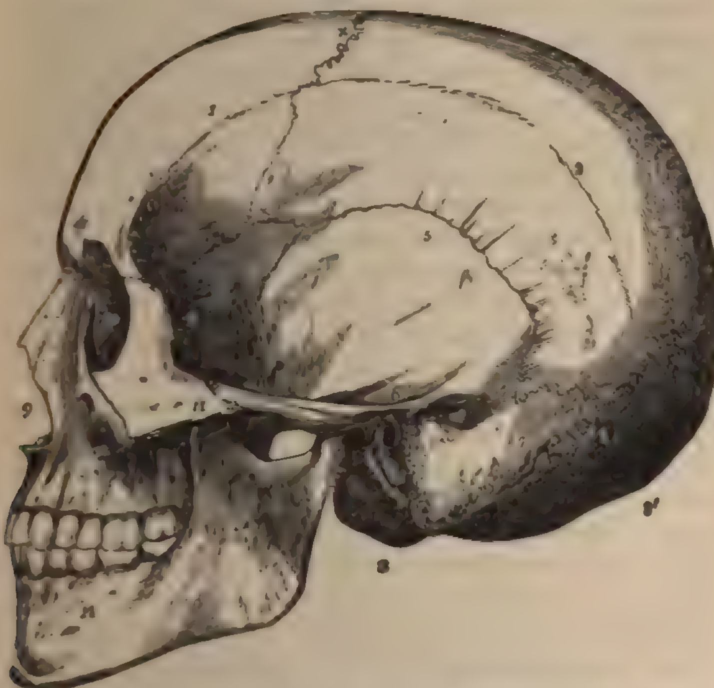
have more than one set of teeth, a first or deciduous set, which is shed, and which is succeeded by a permanent set.

The teeth are imbedded in sockets, so-called *alveolar cavities*, which are contained in the *superior* and *inferior maxillary bones.*

We find both the deciduous and permanent teeth arranged

in the form of two nearly symmetrical rows, an upper row and a lower row. The teeth of the upper row are connected with the alveolar arches of the two superior maxillary bones, or upper jaw bones (see Fig. 2, A. and B.) which, although in close apposition, remain distinct bones throughout life. The teeth of the lower set are imbedded in sockets in the inferior maxillary or lower jaw bone (see

Fig. 3.



LATERAL VIEW OF THE SKULL (QUAIN'S ANATOMY).

Fig. 2, C.) This, which is the only moveable bone of the skull, in the early stages of existence is double, but the two portions subsequently unite in the middle line at the so-called *symphisis* (C. 2), to form a bone having somewhat the form of the horse-shoe. The diagram to which I now point (Fig. 3), must be looked at side by side of the one

which we have just examined. You here see the superior maxillary bones in their complicated relations to the other bones of the face: the relation of the inferior maxillary bone to the cranium: and of the upper to the lower set of teeth. You notice (Compare also Fig. 2, C.), that from the back part of the inferior maxillary bone there ascends almost vertically a part of the bone, technically termed its *ascending ramus*, which terminates above in two processes, the anterior of which, the *coronoid process*, serves for the attachment of the powerful *temporal* muscle, whilst the posterior process, the *condyle* of the inferior maxilla, presents an articular surface covered with cartilage, which fits into a corresponding articular cavity termed the glenoid fossa, on the lower surface of the temporal bones; there being, however, an intermediate plate of gristle (inter-articular fibro-cartilage) between the one articular surface and the other.

In the human adult in the perfect condition, 16 teeth exist in each jaw, viz.: 4 *incisors*, 2 *canines*, 4 *bicuspids*, and 6 *molars*. These, though differing somewhat in form, yet present many characters in common. Anatomists have divided every tooth into three parts, viz.: the crown, the root or fang, and the cervix or neck. The crown is the part of the tooth which projects above the gum, and which is covered by the hardest of all the tissues of the tooth, the so-called *enamel*; the fang is imbedded in the alveolar cavity, whilst the cervix is the somewhat constricted part of the tooth which is embraced by the gums.

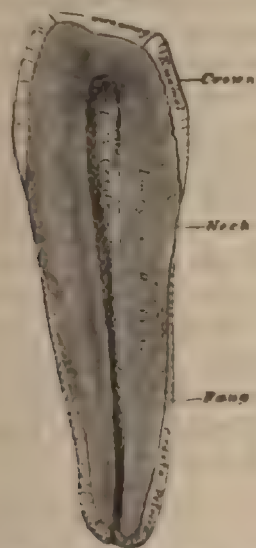
Look at the diagram of the section of tooth to which I now point (Fig. 4), and you will observe not only the parts of the tooth to which I have referred, but also certain other appearances to which I wish to call your attention.

The crown is seen to be covered with a thin layer of the very hard *enamel*, which is found on microscopic examination to be made up of columns of hardened fibres, which remind us somewhat of columns of basalt, and which contains about 96 parts in 100 of mineral matters.

The greater part of the tooth is made up of the structure termed *dentine* or ivory, having essentially the same

chemical composition as bone, but which is seen to be perforated by innumerable tubules, the *dentinal* tubules. The outline of the fang is seen to be covered by a thin layer of a tissue, which presents certain of the anatomical elements of bone and which is termed the *crusta petrosa.* The centre of the tooth you will observe is hollow; here we have the so-called *pulp cavity.* In the living condition this cavity lodges a very vascular structure, "*the pulp,*" composed of connective tissue, which supports

Fig. 4.



VERTICAL SECTION OF A BICUSPID TOOTH, MAGNIFIED (GRAY'S ANATOMY).

blood vessels and nerves. Certain cells of the pulp, so-called '*Odontoblasts*' have processes connected with them and it is these processes which probably enter the dentinal tubules. You will observe that a canal perforates the fang or fangs; it is through this that blood vessels and nerves pass to and from the pulp, and establish a nervous and muscular connection between it and the maxillary bones in the first instance.

Before examining, in as detailed a manner as the short space of time at our disposal permits, the characters of the permanent teeth of man, let me mention two interesting facts: firstly, that the teeth are structures which are formed by a modification of the tissues which enter into the composition of the mucous membrane of the mouth; and, secondly, that the jaws of the toothless infant at birth contain already formed, in great measure, the teeth of the milk set, and, stored away in so-called *cavities of reserve*, the rudiments of nearly all the permanent teeth.

The number and character of the teeth is indicated by anatomists by means of so-called *dental formulæ*, which I may remark, have nothing in common with mathematical formulæ. I shall illustrate the use of these formulæ by writing down before you the formula of temporary dentition and then that of permanent dentition in man.

In these misnamed formulæ we have first of all a vertical line in the centre to indicate the separation between right and left maxillæ and a horizontal line to indicate the separation between teeth of the upper and of the lower jaws. The letters which are above the numbers indicate the characters of the teeth enumerated; thus *i.* stands for incisor; *c.* for canine; *p.m.* for praemolar; *m* for molar. The formula allows us to see at a glance the position of the teeth in the jaws.

FORMULA OF TEMPORARY DENTITION.

$$\begin{array}{ccc|ccc} \text{m.} & \text{c.} & \text{in.} & \text{in.} & \text{c.} & \text{m.} \\ 2 & 1 & 2 & 2 & 1 & 2 \\ \hline 2 & 1 & 2 & 2 & 1 & 2 \end{array} = 20$$

FORMULA OF PERMANENT DENTITION.

$$\begin{array}{cccc|cccc} \text{m.} & \text{pm.} & \text{c.} & \text{in.} & \text{in.} & \text{c.} & \text{pm.} & \text{m.} \\ 3 & 2 & 1 & 2 & 2 & 1 & 2 & 3 \\ \hline 3 & 2 & 1 & 2 & 2 & 1 & 2 & 3 \end{array} = 32$$

Let us now examine very briefly the characters of the different teeth in the adult jaw (Fig. 5).

1st. The incisors. These are eight in number, two on

each side of the middle line both in the upper and lower jaws. Observe the chisel-like cutting edges of these single-fanged teeth, their somewhat convex anterior surface, the little eminences with intervening notches presented by the typical tooth before its cutting surface has been worn down

Fig. 5.

THE PERMANENT TEETH, EXTERNAL VIEW (GRAY'S ANATOMY).

by hard usage, and the fact that the central incisors of the upper jaw are larger than the lateral incisors, whilst the opposite holds true of the lower jaw.

2nd. The canines, four in number, one on each side in each jaw. Note their very long fang, the great convexity of the anterior surface, and its angular point. These are

the teeth which are so largely developed in the dogs and the cats, and which in these creatures are used for tearing their food.

It will be observed by comparing the two dental formulæ before us, that the number of incisors and canines is the same in the child and in the adult.

3rd. The praemolars, eight in number altogether, are not represented in the dental formula of the child.

Observe the broader surface of the crown, as contrasted with that of the teeth we have yet examined; from its presenting two tubercles or *cusps*, these teeth have often been called *bicuspids*. Note that their fang is grooved, indicating that it is composed of two imperfectly coalesced fangs.

4th. The molars, twelve in number altogether, are square topped, offering a broad surface, which is rendered uneven by the four or five cusps or prominences which each presents. Such a surface as fits these teeth to be, as their name implies, *the grinders*. Observe the three strong and curved fangs of the upper molars, the two fangs of the lower molars, each one of which with a groove which indicates generally its bified character. To the most posterior of the molars, as you all know, the name of *wisdom teeth* is given, from the fact of their eruption usually occurring when adolescence has passed, and adult life been entered upon.

Looking now at the skull which I hold in my hand (see Fig. 3), I wish to direct your attention to the fact that the teeth of the upper jaw form a wider arch than, and slightly overhang, those of the lower.

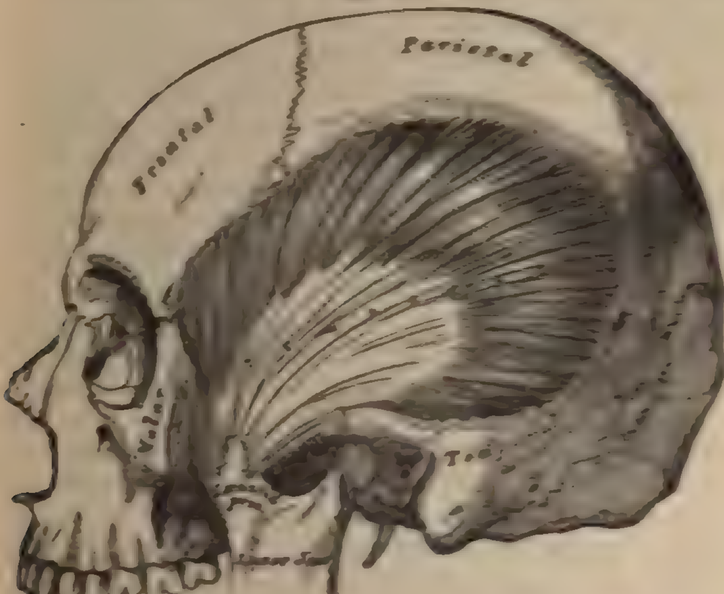
This depends upon the circumstance that the anterior teeth in the upper jaw have a direction obliquely forwards, and the posterior teeth slant outwards, whereas the lower incisors are vertically placed, and the teeth posterior to them are directed inwards. When the jaws are placed in apposition, the teeth of the upper correspond to the intervals between those of the lower jaw; this is brought about by the upper incisors being larger than the lower. Nevertheless the two dental arches terminate nearly in the same vertical

plane posteriorly, because of the larger size of the wisdom teeth of the lower as compared with those of the upper jaw.

Movements of the Human Jaw

The human inferior maxilla, or lower jaw, admits of three different movements: 1stly, A movement of opening and shutting: 2ndly, A movement of advancing and retiring, in

Fig. 6.



THE TEMPORAL MUSCLE, THE ZYGOMA AND MASSETER HAVING BEEN REMOVED (GRAY'S ANATOMY).

which the whole inferior maxilla takes part; and 3rdly, a lateral movement, caused by a modification of the second.

1. *Movement of Opening and Shutting.* The inferior maxilla possesses a condyle (Fig. 2, C), which fits obliquely into the glenoid cavity of the *temporal* bone. This cavity is bounded outwardly by a transverse eminence—the 'emi-

nentia articularis' of human anatomists. The articular eminence enters into the formation of the joint, both it and the glenoid cavity being covered with cartilage.

When the mouth is slightly opened the condyle remains in the glenoid cavity, but if opened widely the condyle advances upon the articular eminence and slips back again when the mouth is closed. The use of the advancing movement of the jaw is to bring the lower row of teeth for a moment in apposition with the upper, and to cut the food as if with a pair of scissors by the retiring movement of the inferior maxilla.

The muscles which are chiefly concerned in raising the upper jaw and closing the mouth are the *masseter*, *temporal*, and *internal pterygoid:* all powerful muscles, stretching from the fixed upper jaw and skull to the moveable lower jaw. Of these the *temporal* muscle arises, as you observe, from the side of the head and behind the temples, and is inserted into the so-called *coronoid process* of the lower jaw bone (Fig. 6). The contractions of this powerful muscle are well seen during the act of mastication in old men whose temples are growing bald. The next muscle, the *masseter*, arises from that strong ridge of bone—the so-called *zygomatic arch*, which may be traced by the finger from the front of the ear to the prominence of the cheek, and is attached to the outer side of the lower jaw; its contraction may be very plainly felt by placing the finger-tips firmly against the part of the cheek corresponding to the ramus of the jaw, while the teeth are strongly clenched. You may see it in the diagram to which I now point, and to which I shall specially direct your attention in connection with the salivary glands (Fig. 7).

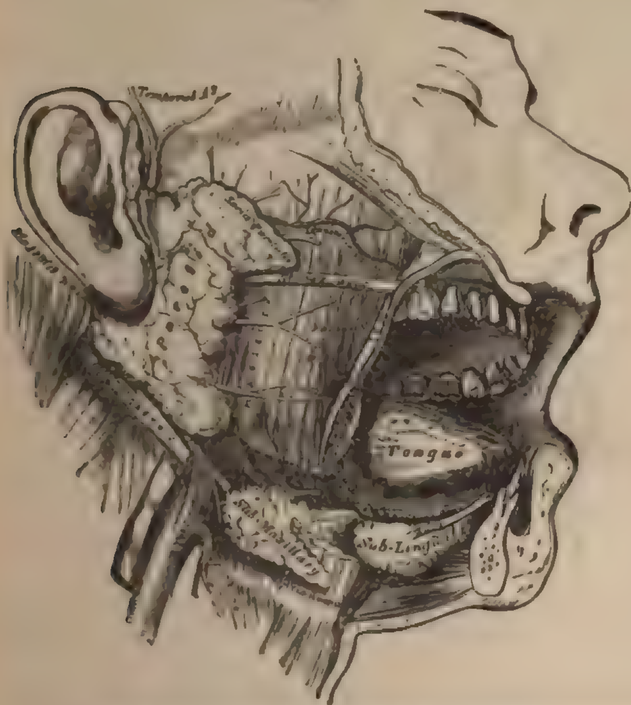
The third muscle of this set is the *internal pterygoid*, which arises from the under portion of the cranium and certain bones of the face, and is attached to the inner surface of ramus of the lower jaw (Fig. 8).

The opening of the mouth is an act which depends partly upon the cessation of contraction of the muscles which close the jaw, partly upon the action of gravity, and

partly upon the contraction of certain muscles, and especially of the so-called *digastric* muscle.

The antero-posterior movements of the lower jaw are effected by means of the external pterygoid muscles (Fig. 8) on each side. These arise from the back of the upper jaw bone, and from certain other bones of the

Fig. 7.



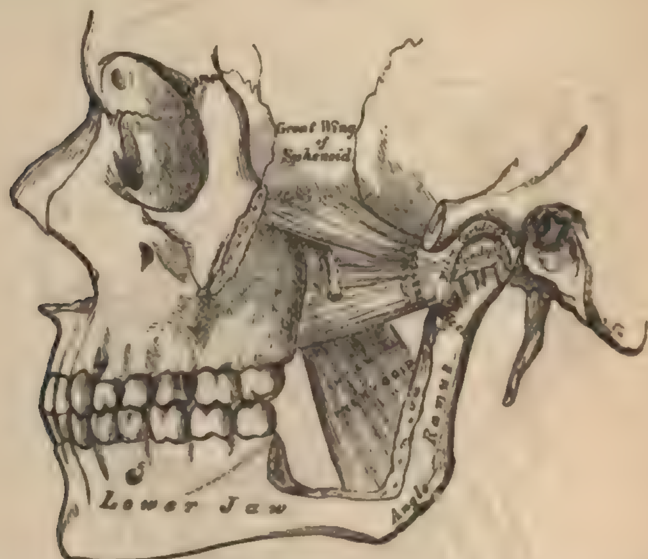
THE SALIVARY GLANDS (GRAY'S ANATOMY).

skull, and stretch in a direction backwards and outwards, to be inserted into the articular process of the lower jaw bone below the articular head. The joint action of the muscles of both sides will project the lower jaw, while the action of one only will tend to sweep the lower jaw round the opposite articulation as a pivot. It is in this way, then, that the lateral movement is effected.

By a combination of the movements which have been described, the biting, pounding and grinding movements of the jaws are effected, which in combination constitute mastication.

It must be pointed out, however, that this mechanical process is greatly aided, firstly, by the pouring out of the

Fig. 8.



THE PTERYGOID MUSCLES, THE ZYGOMATIC ARCH AND A PORTION OF THE RAMUS OF THE JAW HAVING BEEN REMOVED (GRAY'S ANATOMY).

liquid secretion, the saliva, which moistens the food, and prevents its adhering to the sides of the mouth, and afterwards binds together the fragments into a coherent mass or *bolus*; secondly, by the muscles of the cheeks, lips, and tongue, which by their contraction, prevent the matter undergoing mastication from accumulating between the cheeks and lips on the one hand, and the dental arches on the other, and also knead the food into a bolus, and force it between the surfaces of the teeth.

It is difficult to exaggerate the importance of the act of

mastication. When improperly performed, either because of a mere vicious habit of bolting the food, or because of loss of teeth, dyspepsia or indigestion is a frequent, and, sooner or later, the almost necessary consequence.

The digestive juices, whose action we shall study in subsequent lectures, cannot adequately exert their action unless the food have been previously reduced to a moderately fine state of division. The digestion of large masses of food, say by the gastric juice, must, of necessity, be much slower than if they had been broken up into many smaller fragments.

LECTURE III.

THE SALIVARY GLANDS.—SALIVA AND ITS ACTION UPON THE CONSTITUENTS OF FOOD.

THE interior of the mouth is continually moistened by a somewhat viscous, tasteless watery liquid, the *Saliva*, a product of the activity of several so called *Salivary Glands*; the presence of this liquid facilitates the movements of the lips, tongue and cheeks in articulation.

Though essential to proper articulation, the saliva is, however, to be looked upon as one of the digestive juices, and is poured out in much increased quantities when food is introduced into the mouth.

It acts as a solvent of many savoury substances, and as the vehicle which brings them into contact with the end organs of the nerves of taste; by moistening the food it renders more easy the preliminary act of mastication; it prevents the particles of food from adhering to the interior of the mouth, and thus co-operates with the muscular movements of the lips, tongue, and cheeks, in forming the crushed food into a *bolus* which may readily be propelled through the pharynx and oesophagus; lastly, in man and several other animals it exerts, in virtue of the presence of an unformed ferment or *Enzyme*, which is sometimes called "*Ptyalin*," but now more frequently the '*Diastatic*' or '*Amylolytic Ferment*' of the saliva, or '*Salivary Diastase*,' a solvent action upon the starchy constituents of food, and thus initiates the chemical operations to which the food is subjected in its passage through the alimentary canal. The saliva exerts,

therefore, two sets of functions, the mechanical and the chemical, of which the first are undoubtedly the most important, as is shown by the fact that in most animals the saliva is free from [illegible] ferment, and therefore [illegible] any chemical activity whatever.

Situation and Structure of the Salivary Glands.

The glands chiefly engaged in the secretion of the saliva are firstly the Parotid Glands, secondly the Submaxillary Glands, thirdly the Sublingual Glands (see Fig. [illegible]).

The Parotid Glands situated in front of the ear, and in great part hidden behind the ascending ramus of the lower jaw, are in man the largest of the salivary glands, varying in weight between half an ounce and a whole ounce. Each gland has a duct, known as Stenson's duct, after the anatomist Stenon, who discovered it in [illegible]. This duct, whose length is about [illegible] inches, runs over the masseter muscle, and opens on the surface of the mucous membrane of the mouth, at a point opposite the interval between the first and second molar teeth of the upper jaw.

The *Submaxillary Glands*, one on each side, lie under shelter of the lower jaw in a space termed [illegible] the submaxillary triangle. They are a good deal smaller than the parotids, and usually only weigh half an ounce. Each gland has a duct, termed, after its discoverer, *Wharton's duct*, which opens on the summit of a small papilla on either side of the so-called *frenum linguae*.

The *Sublingual Glands* are the smallest of the three pairs of salivary glands, each being about one-third the size of a submaxillary gland. They are situated beneath the mucous membrane of the floor of the mouth, on either side of the frenum. The sublingual glands discharge their secretion by several small ducts, which open on the floor of the mouth, and to which the name of the *ducts of Rivinus* is given.

In addition to the three pairs of salivary glands which I have just enumerated to you, there are numerous glands

stationed in the mucous membrane of the mouth, and especially in that covering the base of the tongue, which contribute to the formation of the saliva,

In structure, all the salivary glands present striking points of similarity, and indeed until recent times they were supposed to be identical.

They all belong to the class of acinous, or compound racemose glands, i. e., of glands which may be divided into so called lobes, each of which depends from, and is connected with a duct, which uniting with other lobar ducts forms the principal duct of the gland, the whole arrangement reminding one of a bunch of grapes.

The main duct, as well as the larger subdivisions, of such a gland as the parotid is lined with cylindrical epithelium ; as the duct subdivides, the character of the epithelium undergoes certain variations with which I need not trouble you. Ultimately, however, the gland duct leads us to the ultimate secreting *acini*, which are usually more or less tubular in form. These secreting recesses are lined by the secreting epithelium cells, which lie upon a so-called basement membrane, which is a transparent thin membrane constituting the most superficial part of the sub-epithelial tissue. Outside of this basement membrane are lymph spaces and meshworks of capillaries.

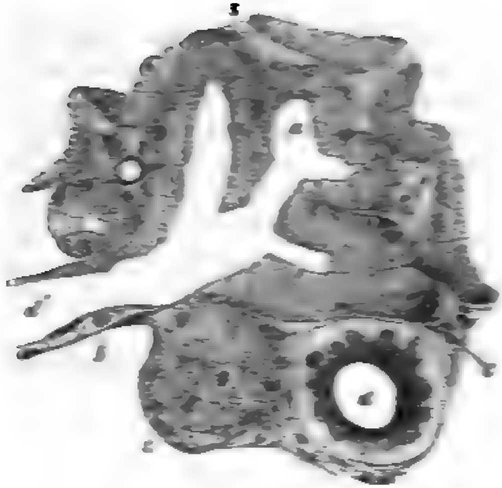
Whilst all the salivary glands present points of great resemblance, both in structure and functions, they are now subdivided into two groups.

According to the researches of Heidenhain, the glands belonging to these groups may be denominated Serous, or albuminous, and Mucous glands, according to the structure of the cells of their acini, their chemical characters, and the nature of the secretion which they elaborate.

To the group of Serous Glands belong the parotid of man and the majority of animals, the submaxillary gland of the rabbit, and some of the glands of the tongue ; to that of Mucous Glands belong the submaxillary and sublingual glands in most animals, some of the glands of the tongue,

and the œsophageal glands. Glands belonging to the former of these classes secrete a fluid containing some, though it may be only a small quantity, of a proteid coagulable by heat, and resembling if not identical with serum-albumin; the mucous glands, on the other hand, as their name implies, secrete a liquid free from albumin, but containing more or less mucin.

Fig. 3.



SECTION OF A MUCOUS GLAND (the submaxillary gland of the dog), showing the commencement of a duct in the alveoli. (Schäfer, Quain's Anatomy, vol 2, p. 581.)

a One of the Alveoli, several of which are in the section shown grouped around the commencement of the duct *d'*; *a* an alveolus not opened by the section; *b*, basement membrane in section; *c*, interstitial connective tissue of the gland; *d*, section of a duct which has passed away from the alveoli, and is now lined with characteristically striated columnar cells; *e*, semilunar group of darkly-stained cells at the periphery of an alveolus.

In the serous glands, the epithelium lining the acini is composed of comparatively small, rounded, or polygonal cells, of which the outlines are not very distinct until acted upon by certain reagents. No cell-wall is present; the protoplasm, which is not coloured by carmine, presents many dark granules, and surrounds an irregularly angular or rounded nucleus which is coloured by carmine.

In the Mucous Glands (see Fig. 9) the characteristic (mucous) cells of the alveoli are large and clear, very faintly granular, with a rounded or oval nucleus near their periphery, surrounded by a trace of protoplasm. They possess a cell-wall, and a strongly refracting process which springs from the cell in the neighbourhood of the nucleus.

In addition to the characteristic mucous cells there are found in the alveoli of most mucous salivary glands when examined in a state of rest, situated at some parts of the periphery (see s, Fig. 9) *i.e.*, lying more external than, and nearer to the membrana propria than, the mucous cells, half-moon-shaped aggregations of small cells, possessed of a round nucleus easily stained with carmine, and containing much albumin ; to these aggregations the term of *demilunes*, or *lunulæ* of *Gianuzzi* has been applied. In some cases we find alveoli in which these small cells are not arranged in demilunes, but form a row of cells lying external to the mucous cells, and completely encircling them.

As I have said, in certain mucous glands the mucous cells are supplemented by the cells of the demilunes, though certain mucous glands, as those of the tongue, exist where the typical mucous cells alone occur.

There are glands, and the submaxillary of man is an example, which are termed mixed glands, inasmuch as some of the acini have all the characters of serous, others of mucous glands.

The researches made during the last few years by Heidenhain, and fully confirmed and extended by Langley and other observers, have demonstrated that in the salivary glands, as indeed in the majority of secreting glands, structural and perfectly obvious microscopic changes occur, which stand in close relation to the different conditions of functional activity.

The resting gland cells may in the case of serous glands be shown to contain a large amount of granular matter (Fig. 10, A). The cells of glands which have been engaged in the act of secretion are found to have diminished in size, and to

have lost much of their granular matter (see Fig. 10 B and C), whilst the matter of the cell stains more easily than before.

Fig. 10.

ALVEOLI OF SEROUS GLANDS.

A, at rest; B, after a short period of activity; C, after a prolonged period of activity (Langley).

The resting gland-cell is large, but possesses comparatively little matter which can be stained by colouring matters, especially by carmine; it contains, instead, a store of material which has been elaborated in, or at the expense of, the protoplasm. This material does not constitute the specific matter of the secretion, but is its antecedent. That it differs chemically in the case of the mucous glands is proved by the fact, cited by Heidenhain, and discovered by Watney and Klein, viz., that whilst *mucin* is stained by logwood, its antecedent (*mucigen*) is not affected by that colouring matter; in all other respects the two bodies are identical. When, however, a gland passes into a state of activity, the gland-cells undergo the following changes, which may proceed simultaneously though not necessarily so:—the stored up matter previously referred to is converted into soluble constituents of the secretion, and at the same time there occurs a growth of the protoplasm of the cells, at the expense doubtless of the richer supply of lymph which bathes the gland during the secretory act.

The period of activity is indeed, in so far as the gland-cell is concerned, a period of removal of ready-made constituents of secretion, and in some cases, as in the mucous-bearing cells of the mucous glands, a period of destruction of cells laden with such constituents; but at

the same time, in all cases, a period in which the protoplasmic constituents of the cells generally increase, and active proliferation of secreting cells occurs.

The Nerves which supply the Salivary Glands.

Each salivary gland is supplied by at least three classes of nerve fibres, viz., secretory fibres, vaso-constrictor and vaso-dilator fibres, of which the first and the third are conveyed to the glands in branches of cerebral nerves; these are, the chorda tympani for the submaxillary and sublingual and the auriculo-temporal (which, however, derives them through communications with the otic ganglion) for the parotid. The second class of vaso-constrictor or vaso-motor fibres run in sympathetic trunks. When, therefore, one of the cranial branches supplying a gland is stimulated, there occur two acts, viz., secretion and simultaneous dilatation of blood vessels; that these two acts are not absolutely interdependent is proved by the fact that certain drugs paralyze the one set of fibres, leaving the other intact. When, on the other hand, the sympathetic filaments supplying the gland are stimulated, the blood-vessels of the gland contract, and there is produced a small quantity of saliva differing in physical characters and chemical composition from that obtained under the circumstances first referred to. According to Heidenhain, however, in each of the two kinds of nerves supplying a salivary gland there exist, besides the vascular nerve-fibres, secretory and trophic fibres, though the number of one or other of these classes may be insignificant,—the secretory predominating in the cranial nerve branches, the trophic in the sympathetic. Stimulation of secretory fibres leads, according to Heidenhain, to an increased flow of water; stimulation of the trophic to an increased secretion of specific substances, and to an increased production of protoplasm.

When a salivary gland passes from the state of rest into that of activity it is at once the seat of an increased blood flow, which is associated with the dilatation of the blood-

vessels of the organ. Under these circumstances, the blood leaving the gland presents a florid arterial instead of a venous colour, which characterizes that of the organ when at rest. This vascular dilatation is explained by the coming into action of the before-mentioned vaso-dilator fibres; it is independent of the act of secretion.

Heat evolved in the Salivary Glands.

As was shown in a now classical investigation of Ludwig, when the salivary glands are thrown into activity there is a rise in temperature, so that the temperature of the saliva leaving the submaxillary gland may exceed by 1°·5 C. that of the blood flowing to the gland. This rise in temperature cannot be explained by a study of the chemical characters of the salivary secretion, but is doubtless the result of the increased chemical changes which necessarily accompany the act of secretion in the gland-cells, and which chiefly affect their protoplasm.

The Function of Saliva not an act of Filtration.

That the secretion of saliva (and indeed secretion in general) is not a mere act of filtration was proved by Carl Ludwig, when he showed that saliva can be secreted by a gland though the pressure within it is many times higher than that of the blood circulating through the arteries which supply it. On many grounds it may be positively asserted that the secreting cells are the primary agents in the withdrawal from the blood of the water necessary for the secretion, though the exact nature of the process is yet unknown; similarly, on the grounds stated below, we know that within the protoplasm of the gland-cells are formed the characteristic soluble constituents of the secretion.

Quantity of Saliva secreted.

In the case of saliva, as in that of other digestive juices, we possess no mode of determining, in a reliable manner,

the amount of the secretion which is poured out in the physiological condition.

Wright calculated the daily secretion of mixed saliva at 10 or 12 ozs. Mitscherlich calculated the probable secretion to amount to 8 to 10 ozs. daily.

According to Tuczek, the salivary glands of an adult man secrete during mastication *at the rate of* 1300 grammes of saliva for each 100 grammes of gland-substance, the saliva containing 6·3 grammes of solid constituents, of which 3.9 grammes consist of organic matters.

Physical and Chemical Properties of Mixed Saliva.

Normal saliva is, when perfectly fresh, a clear, transparent, viscid fluid, which on microscopic examination is found to hold in suspension, but very sparsely distributed through it, cells of squamous epithelium, which have become detached from the walls of the mouth, besides certain cells denominated salivary corpuscles ; these cells, which present some resemblance to white blood corpuscles, are much more globular, and contain within their interior granules which exhibit in a very remarkable manner *Brownian* movements.

The specific gravity of the mixed saliva of man varies between 1·002 and 1·006, the mean being, however, about 1·003.

Perfectly normal human saliva possesses a faintly alkaline reaction, which is least marked after a long fast, and most distinct when the flow of the secrection is at its height. In some persons, especially in the morning, the saliva is found to possess an acid reaction, which is however due to fermentative changes.

Frerichs found that 100 grammes of saliva secreted by himself during smoking required 0·150 grammes of sulphuric acid to neutralize it.

The table to which I now direct your attention exhibits the results of analyses of the saliva made by the most reliable observers.

Results of Quantitative Analyses of mixed Human Saliva.

The following analyses exhibit the results obtained by Frerichs, Jacubowitsch, and Herter:

——	(1) Frerichs.	(2) Jacubowitsch	(3) Herter.
Water in 1000 parts. . . .	994·10	995·16	994·698
Solids	5·90	4·84	5·302
Soluble organic matters . . .	1·42	1·32	3·271
Epithelium	2·13	1·62	?
Potassium sulpho-cyanate . . .	0·10	0·06	?
Inorganic salts	2·19	1·82	1·031

You observe how very abundant a constituent of the saliva is water, and that of the 5 or 6 parts of solid matters contained in 1000 parts of the mixture, about one half are organic matters and the other half mineral.

First let me dispose of the salts of the saliva. The chief of these are salts of sodium. It is a strange fact that the saliva always contains a soluble *sulpho-cyanate*, rendered evident by the red colouration which is shown when a little solution of a ferric salt is added. Among the saline constituents are traces of nitrites and some ammonia.

Passing next to the organic matters, we find that in largest quantity are suspended epithelium cells, which have been shed from the gland and passed into the secretion. Of the organic solids which are in a state of solution in the liquids, there are two which require our attention. The first of these is a body called *Mucin*, which is precipitated by acids, and which we find in many more or less viscid secretions, a body related to and unquestionably derived from the true albuminous substances of certain of the secreting cells. The mucin of the mixed saliva of man is mainly derived from the secretions of the submaxillary and sublingual glands.

The Diastatic Ferment.

The second and most important constituent is the *Diastatic Ferment*, sometimes called *Salivary Diastase* and also *Piyalin.*

This, in many respects the most interesting constituent of the saliva, and which is invariably present in this secretion in man, is by no means a usual constituent of the saliva of the lower animals.

It was Leuchs who first ascertained that when human saliva is mixed with starch it gradually dissolves it, with the formation of a body which possesses the reactions of grape-sugar. Schwann confirmed this discovery, the truth of which soon received general assent, though the great majority of scientific men declared themselves of the opinion that in the living organism the saliva could not exert this action to an appreciable extent, and that its function depended essentially upon its watery character aiding gustation, mastication and deglutition.

In 1845, Mialhe discovered that when filtered human saliva is mixed with 5 or 6 times its weight of absolute alcohol, a small quantity of a flocculent body is deposited, which he collected and dried at the temperature of the air. This body he found to be insoluble in strong alcohol, but soluble in water and very weak alcohol. He discovered its remarkable property of converting boiled starch into sugar, and from the resemblance to, indeed the apparent identity with, the ferment which Payen and Persoz had lately separated from germinating barley, he applied to it the name of *Animal* or *Salivary Diastase.*

He announced that one part of this body was able to convert into sugar 2000 times its weight of starch.

Attempts to separate this ferment in a state of purity have failed, though we have succeeded in learning a great many facts relating to its properties, and the action which it exerts. To some of these facts I now wish to direct your attention.

Action of Saliva on Starch.

The body which we call starch $(C_{12}H_{20}O_{10})_n$ is an organic compound of carbon, hydrogen, and oxygen, which is formed in the interior of certain vegetable cells, and which occurs in the form of granules, differing somewhat in microscopic characters, according to the vegetable which yields it. These granules, which occur most abundantly in certain grains and roots, present an appearance under the microscope which indicates that they are composed of a large number of concentric layers.

When the starch grains are boiled in water they swell greatly, and we obtain so-called starch paste.

I have to tell you, that the salivary ferment, and therefore the saliva, is almost without any action on unboiled starch. When added, however, to starch paste, the action of saliva which, like human saliva, is rich in diastatic ferment is most striking.

In this beaker I have placed about a pint of a gelatinous solution containing potato starch. You observe how viscous is the solution as I pour it from one vessel to the other. I have taken the precaution of having the starch paste heated to about the temperature of the human body, and I now add a solution which contains some salivary ferment. You observe that almost instantly a great change comes over the gelatinous starch, which becomes perfectly limpid and transparent. The first action of the ferment is to convert gelatinous into soluble starch, that is into a body having the same reactions as insoluble starch. Like the latter body it strikes a beautiful blue colour with iodine, and is precipitated from its solutions by tannic acid and by alcohol.

But the production of soluble starch is only the first stage in the action of saliva. When the diastatic ferment acts for a longer time than suffices for the production of soluble starch, or when it is added in considerable quantities to starch paste, it is found that iodine no longer produces a

blue colour, but either a violet colour, or a red colour, or a more or less deep yellow colour, and lastly no perceptible colouration. The red colour produced by iodine is due to the production from starch of certain so-called *dextrins* characterised as *Erythrodextrins*, of which there are probably two distinct members. The yellow colour indicates the disappearance not only of soluble starch, but of erythro-dextrins, and the production of certain so-called achroo-dextrins.

All these dextrins are isomeric with, and are therefore represented by the same empirical formula as starch, though, as will be explained immediately, they are bodies of smaller molecular weight.

No sooner has the diastatic ferment commenced to act upon boiled starch, than we are able to detect in the solution the presence of a body belonging to the group of sugars, and this body was until lately supposed to be identical with grape-sugar. Its presence may be demonstrated by the following, amongst other, tests :

1. When the solution is treated with a drop of a solution of copper sulphate, and then with an excess of solution of caustic potash or soda, a deep blue liquid is obtained which, when boiled, deposits a yellowish red precipitate of anhydrous cuprous oxide. The same reaction is obtained with the reagent known as 'Fehling's Solution,' and which contains dissolved in water copper sulphate, an alkaline tartrate, and much sodium hydrate.

2. When boiled with an equal volume of a solution of potassium or sodium hydrate, a yellow amber colour is developed, which becomes darker in shade as the boiling is continued.

It is now known that the sugar produced by the influence of diastatic ferments upon starch is identical with that formed in the malting of barley, and to which the name of Maltose is given. Maltose is not isomeric with glucose, but with cane sugar. Its formula when crystallized is : $C_{12}H_{22}O_{11} \cdot H_2 O$. The reducing power of maltose on cupric oxide is to that of glucose in the ratio of 61 : 100 ; it is not directly susceptible of the alcoholic fermentation.

In the first stages of the diastatic digestion of starch there are large quantities of dextrins and little maltose present, but as the action proceeds, the dextrins diminish and the maltose increases in amount.

We may form some idea of this process in the following manner. Let us conceive the molecule of starch to be made up of an aggregation of *n* molecules, each of which is represented by the empirical formula, $C_{12}\ H_{20}\ O_{10}$. There are some reasons for believing that the value of *n* is in the case of soluble starch 10. Now under the influence of the diastatic ferment this complex starch molecule combines with the elements of water, and the result is the production of a dextrin having a lower molecular weight than starch, together with a molecule of maltose; thus:

$$\underbrace{(C_{12}H_{20}O_{10})10}_{\text{Soluble starch.}} + \underbrace{H_2O}_{\text{Water}} = \underbrace{(C_{12}H_{20}O_{10})9}_{\text{Erythro-dextrin }\alpha.} + \underbrace{C_{12}H_{22}O_{11}}_{\text{Maltose.}}$$

But this first dextrin, in the presence of diastatic ferment, under suitable conditions again combines with the elements of water, thus:

$$\underbrace{(C_{12}H_{20}O_{10})9}_{\text{Erythro-dextrin }\alpha} + H_2O = \underbrace{(C_{12}H_{20}O_{10})8}_{\text{Erythro-dextrin }\beta} + \underbrace{C_{12}H_{22}O_{11}}_{\text{Maltose.}}$$

The newly formed dextrin, however, again combines with the elements of water, and successively there are produced dextrins of smaller molecular weight, until the final product of the diastatic digestion of starch may perhaps be represented by the equation.

$$10\ \underbrace{(C_{12}H_{20}O_{10})}_{\text{Starch.}} + 8\ \underbrace{H_2O}_{\text{Water.}} = \underbrace{(C_{12}H_{20}O_{10})_2}_{\text{Achroo-dextrin.}} + 8\ \underbrace{(C_{12}H_{22}O_{11})}_{\text{Maltose.}}$$

The action of salivary diastase on starch, like that of the other digestive ferments is affected remarkably by certain conditions, of which temperature is, perhaps, the most important. At the temperature of the body of warm-blooded animals it proceeds with great rapidity; the limits of temperature highly favourable to the diastatic action being between 30°C. and 45°C. If the temperature be

however raised to between 60° C. and 70° C., the ferment is destroyed and all diastatic action arrested.

Although exerting an action similar to that of vegetable diastase, the salivary diastase is not identical with it, as is proved by the following facts; the salivary diastase is killed by a temperature of 60°–70° C., whilst the vegetable diastase acts most potently at 60°, and is only killed by a temperature of 80° C. Again salicylic acid stops the action of vegetable diastase when present in the proportion of 0.05 per cent., whereas it must be present in the proportion of 1 per cent. to exert a similar action upon the salivary diastase.

Have the Different Salivary Glands Different Functions?

In physical properties and in chemical composition, the secretions of the different salivary glands present certain peculiarities, upon which the time at my disposal forbids me to dwell at length. Thus the '*parotid* saliva' is the most watery, and the least viscid, and contains an albuminous substance similar to serum-albumin; and 'submaxillary' and 'sublingual' saliva are characterized by a greater proportion of solids, and by the presence of more viscid mucin.

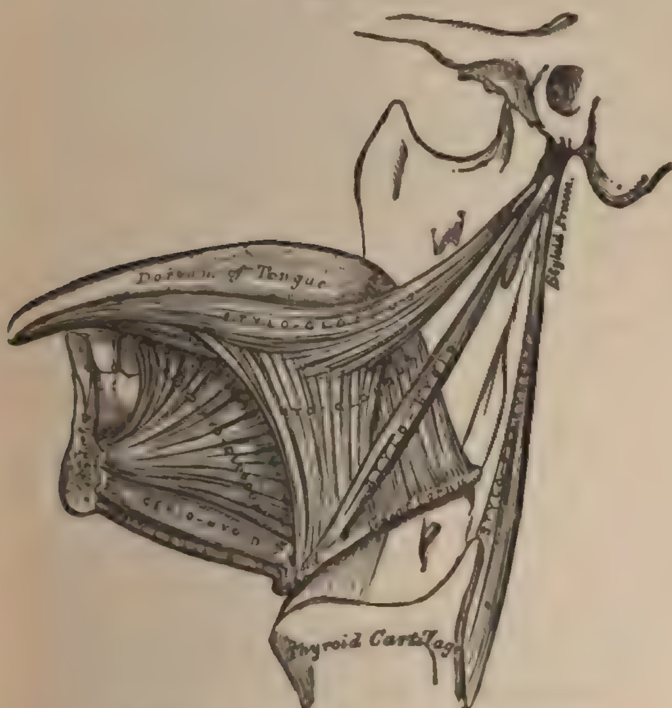
The great French physiologist, Claude Bernard, strove to establish a certain connection between the secretions of different salivary glands and certain functions. Thus, he showed that parotid saliva is, essentially and primarily, connected with the function of *mastication*, so that in those animals, as herbivores, in which mastication is a very elaborate and complex process, the salivary glands are most developed, and are larger in proportion to the other salivary glands. Similarly he showed that submaxillary saliva was connected more particularly with *gustation*, its secretion being stimulated by savoury food, or by mental emotions referring to food, whilst the secretion of parotid saliva accompanies the movements of the jaws.

The sublingual glands and saliva, he believed, though on less cogent grounds, to be subservient to the act of *Deglutition*.

Deglutition.

After the food has been reduced to a proper consistency by the combined influence of the mechanical movements of the jaws, tongue, and cheeks and the action of the saliva, it is rolled into a mass or *bolus* ready for swallowing. The bolus is pushed on the dorsum of the tongue, which is

Fig. 11.



THE MUSCLES OF THE TONGUE (GRAY'S ANATOMY).

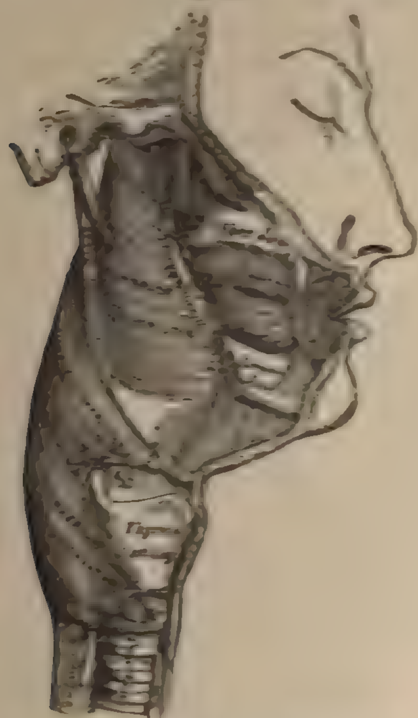
hollowed into a shallow trough to receive it. It is easy to conceive how this shape of the tongue is brought about when we consider that the tongue is provided with vertical fibres, with horizontal antero-posterior fibres, and with horizontal lateral fibres, in addition to its extrinsic muscles.

The tip of the tongue is then raised against the hard palate in such a manner as to form an angle in which the bolus lies. By the approximation of the tongue to the palate the angle is lessened and the bolus is, in consequence, driven backwards. This constitutes the first stage in the act of swallowing, and is a voluntary act. At the end of the first stage the morsel of food has passed beyond the level of the anterior pillars of the fauces. The acts of the second stage are very complicated, and probably are entirely involuntary. The posterior pillars of the fauces approach one another in the middle line, and the uvula falls into the space left between them. The fleshy curtain thus extemporised is then drawn up towards the hind wall of the pharynx, which is drawn a little forwards and upwards to meet it. Thus the passage into the nose is completely shut. Meanwhile the vocal cords of the larynx draw near to one another; the epiglottis is pushed backwards over the larynx, and the whole larynx is drawn suddenly upwards and forwards beneath the root of the tongue. In this manner the entrance into the respiratory passages is protected. Finally, the anterior pillars of the fauces are made to meet over the tongue in order to prevent the regurgitation of the food. There is but one way open to the bolus, the sudden drawing forward of the larynx and the base of the tongue in fact "cuts the ground" from under the ball of food, which thereupon falls into the grasp of the "constrictors" and enters upon the third and final stage in the act of deglutition. This, even more certainly than the second stage, is purely involuntary. The constrictors contract from above downwards and force the morsel of food into the upper portion of the œsophagus. Once in the gullet, the mass of food is driven downwards by the so-called "peristaltic" movements of the tube—the circular fibres contract one after another from above downwards, lessening the calibre of the tube in successive stages, whilst the longitudinal fibres seem to have the function of drawing the tube over the bolus as a stocking is drawn over the foot.

Deglutition is a reflex act, in so far as it is involuntary,

the centre for which lies in the medulla oblongata; destruction of this centre implies incapacity to swallow. The centre, though normally under the influence of the higher centres, may, however, act quite independently of these, as is evidenced by the fact that animals have occasionally

Fig. 22.



THE MUSCLES OF THE PHARYNX AND THE RELATIONS OF THE PHARYNX TO THE MOUTH, THE ŒSOPHAGUS, THE LARYNX AND TRACHEA (GRAY'S ANATOMY).

survived for a short time in which the cerebral hemispheres were absent, and have yet been able to suck and to swallow. Although the excised gullet often exhibits a true peristalsis, which doubtless depends upon a local nervous mechanism, the normal movements in the body seem to be regulated from the medulla oblongata. In curarised animals the

pneumogastric nerves seem to have some inhibitory influence over the movements of the gullet, as these become very active when the vagi are cut or the medulla oblongata is destroyed.

At the entrance of the stomach the food meets the barrier opposed by the contracted cardiac orifice; the contraction must be overcome before the food can gain admittance. The relaxation is certainly an active process under the control of the medulla oblongata through the vagus nerve, since section of the vagi causes a block to the progress of food from the œsophagus into the stomach.

LECTURE IV.

THE STRUCTURE OF THE STOMACH.—THE PROCESS OF SECRETION OF GASTRIC JUICE.—GASTRIC DIGESTION.

AT the conclusion of my last lecture I drew your attention very briefly to the process of deglutition or swallowing, which we saw was in part voluntary but mainly involuntary, and which has for its object the conveyance of the *bolus* of food from the cavity of the mouth through the *pharynx* into the œsophagus or gullet. I was compelled to pass over very briefly the remarkable combination of mechanisms by which the bolus in its passage through the pharnyx is prevented from entering either the nasal passages or the larynx and trachea.

The opening of the œsophagus into the stomach is guarded by a sort of sphincter, which is during life habitually closed, but which opens when food presses upon it, closing after its passage so as to prevent its return from the stomach. This sphincter is formed by a contraction of certain of the fibres of the muscular coat of the stomach specially developed with this object.

The Form and Relation of the Stomach.

The stomach, as we have already seen, is a saccular dilatation of the alimentary canal situated between the œsophagus on the one hand, and the small intestine on the other (Fig. 13).

It is situated in the upper and anterior part of the abdominal cavity immediately behind its interior wall. It

occupies the region of the abdomen known as the left hypochondrium and the epigastric region.

The form, dimensions and position of the stomach vary according as it is empty or full.

Fig. 13.

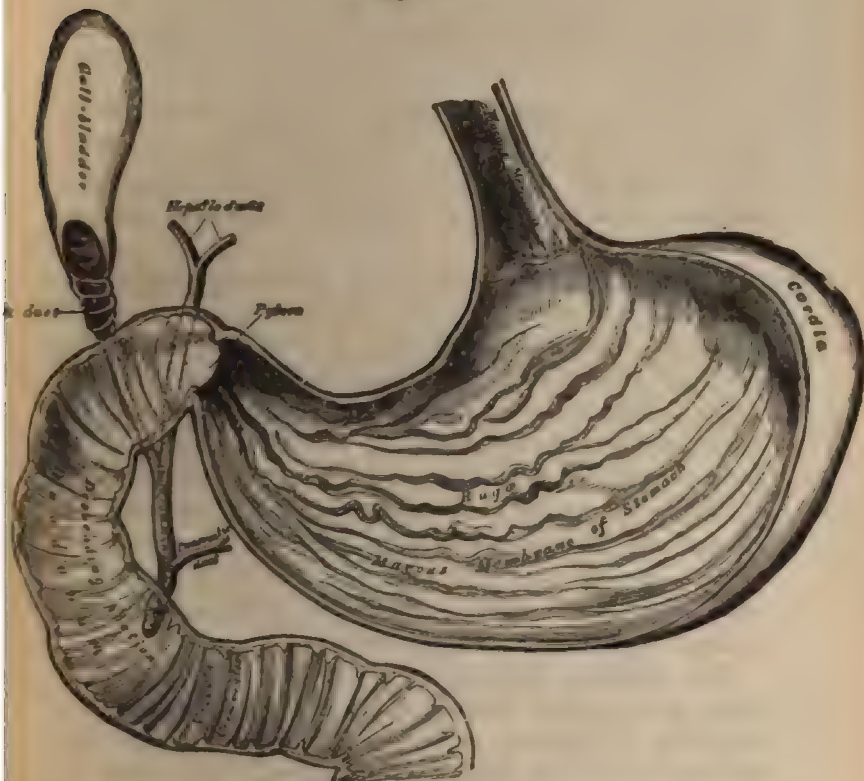
THE STOMACH WITH ITS PERITONEAL COAT REMOVED, EXHIBITING THE MUSCULAR COAT (GRAY'S ANATOMY).

"When moderately full it is about one foot in length, whilst its greatest transverse diameter is four to five inches.

"The general shape is pyriform, and it may be observed as possessing two extremities, two surfaces, and two borders (see Fig. 13). The larger extremity, called the *fundus*, *cardiac extremity*, or *great cul de sac*, is directed upwards so as to be in contact with the under surface of the diaphragm, whilst the smaller end, *pyloric* or *duodenal* extremity, is directed downwards, curves to the right, and becomes continuous with the duodenum. The *surfaces* form the *anterior* and *posterior* walls of the stomach. When the organ is empty the walls are flattened, and in apposition with each other by their inner surfaces; but when it is distended they are curved; the anterior convex surface, directed forwards and upwards, is in relation with the anterior abdominal wall,

the diaphragm and the under surface of the liver; the posterior surface, also convex, directed backwards and downwards, is in relation with the diaphragm, pancreas, transverse part of the duodenum, spleen, left kidney, and supra-renal capsule. The *borders* of the stomach are curved and unequal in size; one is

Fig 14.



THE INTERIOR OF THE STOMACH AND DUODENUM, WITH THE ENTRANCE INTO THE DUODENUM OF THE COMMON BILE DUCT AND THE PANCREATIC DUCT (GRAY'S ANATOMY).

convex, about three times as long as the other, and is named *the greater curvature;* the other is concave and forms the *lesser curvature.*

"The curvatures are so arranged that the greater has its convexity directed downwards and to the left, where it lies in relation to the transverse colon and the special flexure of the colon. The lesser curvature has its convexity directed upwards and to the right; for the

most part it is to the left side of the spinal column, with which it is almost parallel; it lies in relation to the cœliac axis.

"The œsophagus opens into the stomach at the upper end of the lesser curvature, and the cardiac orifice lies behind and opposite to the sternal fourth of the seventh left costal cartilage. Above this orifice the stomach expands into the fundus, which is situated in the highest part of the left hypochondrium, and occupies therefore the summit of the vault of the left half of the diaphragm. At the lower and right end the two curvatures lie almost horizontally in the epigastrium, and terminate at the pylorus, where the stomach becomes continuous with the duodenum.

"The pylorus, or gate of the stomach, is situated in the epigastrium about three fingers' breadth below the ensiform cartilage, and immediately to the right of the mesial plane. The junction of the stomach with the duodenum is marked by a circular constriction externally, called the *pyloric constriction*, and by a valve internally, the *pyloric valve*." *

The stomach is described as possessing four coats. Proceeding from without inwards, there are a *serous* or *peritoneal* coat, a *muscular* coat, a *cellular* or *submucous* coat, and most internally the *mucous coat* or *mucous membrane*, which lines the organ and which is continuous with that lining the remainder of the alimentary canal. I have only time to allude to the extreme smoothness of the glistening peritoneal coat, rendering perfectly easy all movements of the stomach in reference to contiguous viscera—a peritoneal coat which has the characters of all serous membranes, and which most superficially presents a single layer of flattened endothelial cells.

The *muscular* coat, of considerable thickness and of great physiological importance, is composed of sheets of unstriped involuntary muscular fibres arranged in two principal layers, an external longitudinal layer, and an internal circular layer, to which must be added an oblique layer chiefly developed at the cardiac end of the stomach.

The *submucous* or cellular coat is composed of connective tissue, and lodges the larger vessels and lymphatics and nerves and nerve ganglia entering and issuing from the mucous membrane.

* 'An Introduction to Human Anatomy,' by William Turner, M.B. Edinburgh: Adam and Charles Black, 1877, p. 685.

Microscopic Structure of the Mucous Membrane of the Stomach.

The mucous membrane of the stomach is a thin membrane, presenting prominent folds, or *rugae*, most abundant at its pyloric end, and which disappear when the organ is distended. With a magnifying glass the mucous membrane is seen to present innumerable pits or *alveoli*, which are separated from one another by intervening ridges, at the bottom of which are the open mouths of the gastric glands, which are tubular glands, simple or compound, which occupy nearly the whole thickness of the mucous membrane.

In some animals, typically in the dog, the mucous membrane does not present one uniform appearance to the naked eye, nor is its structure identical in all parts. In the pyloric region it is less vascular, and appears thicker, though, as Heidenhain points out, it is here much poorer in glandular structures than at the fundus.

In the stomach of all animals there are observed two sets of glands, which formerly used almost invariably to be classified by English writers, as (*a*) peptic, and (*b*) mucous glands, to indicate the view, then held, that the first secreted gastric juice, whilst the second merely secreted mucus. In the dog, the former are absent from the pyloric region, but occupy the mucous membrane of the fundus and curvatures; they are therefore often spoken of as the *glands of the fundus.* On the other hand, the other glands are spoken of as the *pyloric glands.* In some animals where, as in the dog, these two structurally different regions of the stomach are observed, an intervening region, with transitional forms between these two sets of glands, has been described.

The whole mucous membrane of the stomach, with its depressed alveoli and the intervening ridges, is covered by cylindrical epithelium cells, similar to those of the intestinal tract. These epithelium cells are mucus-forming cells, and

amongst them we often observe, especially during digestion, mucus-secreting goblet-cells. The epithelial cells lie upon a basement membrane composed of apposed endothelium-like cells.

The Glands of the "Fundus."

At the fundus of the stomach the mucous membrane appears thinner, but it contains a far greater amount of glandular elements than are found in the pyloric region. The individual glands are deeper, and they are separated from one another by a much smaller quantity of connective tissue.

The Peptic glands (see Fig. 15), are usually arranged in groups of four or five. The open mouths at the bottom of the alveoli lead into ducts lined by cylindrical epithelium; "into each of these ducts open two or three tubes, the gland tubes proper."

In the gland tube we may distinguish, with Klein, a somewhat constricted *neck*, and a main part the *body*, which increases in width as it proceeds towards the blind extremity or *fundus*.

The gland tube possesses a *membrana propria*, or basement membrane, upon the inner surface of which is placed the secreting epithelium, and outside of which are blood-vessels, lymphatics and nerves.

It has been said, that the epithelium lining the duct common to several secreting tubes is columnar; in the glandular tubes themselves epithelium cells of two kinds are observed. Firstly, large ovoid granular cells, with oval nuclei, are seen lying against the basement membrane and causing it in some places to bulge outwards. These are the *peptic cells*, properly so called, of the older English writers, the *border cells* of some writers, the *delomorphous cells* of Rollet; they do not form a continuous layer, but occur at intervals.

Situated internal to them and between them are cylindrical or cubical cells, the so-called *adelomorphous cells* of Rollet, which have been called *principal cells* by Heidenhain,

and which may most fitly be described as the *central* cells of the peptic glands. These central cells are recognised as essentially similar, both in structure and function, to the deeper columnar or more properly cubical cells which alone line the interior of the fundus of the pyloric glands. Heidenhain points out, however, that the principal cells of the peptic glands present a coarse granulation which hides the borders of the separate cells, whilst the cells of the pyloric glands contain a much finer granular matter which allows of their borders being distinctly seen. The lumen of the peptic glands is an exceedingly narrow canal, and contrasts with the much wider canal which penetrates to the depths of the pyloric glands.

The Pyloric Glands.

The characters of the pyloric gland (see Fig. 15) are thus summarized, and compared with those of the peptic glands, by Dr. Klein:—"The duct is proportionately very long; it amounts to half or more of the whole length of the gland: two or three tubes open into the duct by a very short neck, which represents the narrowest part of the gland: the body of the gland is branched into two or three tubes, which are wavy and convoluted; the lumen of the neck, but especially that of the body of the gland, is much larger than in the corresponding parts of the peptic gland; the lumen in the body of the former glands being many times longer than that of the latter. The epithelium covering the surface of the mucosa and lining the ducts in the pyloric region is exactly the same as in the rest of the stomach. The epithelium lining the neck and body of these glands is a continuation of that of the duct; but, as in the case of the peptic gland, so also here the cells are shorter and more opaque in the neck than in the body. In this latter the cells are fine, more or less transparent, columnar cells; in no part are there parietal cells," &c.

As I shall tell you in the sequel, the product of the activity of the glands of the stomach is a peculiar liquid,

Fig. 15.

A CARDIAC GLAND FROM THE DOG'S STOMACH, HIGHLY MAGNIFIED (KLEIN AND NOBLE SMITH).

a duct or mouth of the gland ; *b* base or fundus of one of its tubules. On the right the base of the tubule more highly magnified ; *c* central cell ; *p* parietal cells.

the gastric juice—a liquid which may be looked upon as an aqueous solution of hydrochloric acid and of a ferment called *pepsin*. It has been conclusively proved that the latter body or perhaps an immediate precursor of it which we may term *pepsinogen*, is formed in part in the cubical cells which line the

Fig.

A CARDIAC GLAND OF SIMPLE FORM, FROM THE BAT'S STOMACH (LANGLEY).

c columnar epithelium of the surface; n neck of the gland, with central and parietal cells; f base or fundus, occupied only by principal or central cells, which exhibit granules accumulated towards the interior of the gland. (From Quain's Anatomy).

deeper parts of the pyloric glands, but chiefly in the central cells of the glands of the fundus. The acid of the gastric juice is, however, formed in the parietal ovoid cells of the glands of the fundus. You may therefore look upon these glands as the *oxyntic* (Langley) or acid-forming glands of the stomach, whilst we admit that the function of forming

the principal stomach ferment, *pepsin*, is shared by both the groups of gastric glands, though unquestionably the glands of the 'fundus' are much the more important.

An Historical Restrospect concerning Gastric Digestion.

As I have already hinted, the processes going on in the stomach are divisible into mechanical and chemical, it

Fig. 17.

A PYLORIC GLAND, FROM A SECTION OF A DOG'S STOMACH (EBSTEIN, TAKEN FROM QUAIN'S ANATOMY).

being well understood that *vital* apparatus contributes to the production of the physical and chemical conditions which are in operation. And firstly, let us confine our attention to the chemical or chemico-vital changes which

the food undergoes in the stomach. Our object must be to explain the changes which cause the merely broken down mixture of alimentary substances which enters the stomach to be partly dissolved and the remainder broken up further into the pulpy substance to which the term *chyme* has been applied. The agent effecting the changes which the food undergoes in the stomach is an acid fluid, termed the gastric juice, which is secreted by the gastric glands.

That the gastric juice is in reality the active agent in the digestive process of the stomach is proved by the following facts.

Firstly, the food is dissolved in the stomach when no other influence except that of the gastric juice can be exerted on it, and secondly, the food is dissolved by the gastric juice, even outside of the stomach, providing the temperature be sufficiently high.

Before entering into a minute account of the present state of our knowledge of the action of the gastric juice, it will be instructive to trace the more salient points in the history of the subject.

Many of the ancient physiologists held that the process of digestion was one of maceration, or as they termed it, *coction*, *i.e.* that the food was merely broken down under the combined influence of moisture and warmth. Again it was thought that digestion was merely a process of trituration; this was the result of false inference by analogy with the fowl's gizzard. Observers of the last century proved that it could not be mere trituration, but that the movements of the stomach merely aided the solvent action of the gastric juice. This conclusion was first arrived at in 1752 by the French naturalist Reaumur, who experimented on a tame buzzard, which, like the owl, hawk, &c., swallows its food and subsequently regurgitates the hairs and other undigested matters. He caused the buzzard to swallow food placed in little metallic tubes shut at one end and covered at the other by muslin, so as to preclude the possibility of the food being triturated and yet permitting the gastric juice to exert its solvent action.

He found that the food was dissolved in the tube. He ascertained that even bone became softened in it. He placed a piece of sponge in the tube, and introduced it into the stomach, and he obtained the sponge soaked with gastric juice.

After Reaumur, Dr. Stevens, in an Inaugural Thesis presented in 1777 to the University of Edinburgh, detailed some very curious experiments. He availed himself of the presence in Edinburgh of an Hungarian, who had the power of swallowing stones, and then regurgitating them. Stevens caused this man to swallow little silver balls with holes like a sieve, so constructed as to admit of being filled with food and closed by screwing. Dr. Stevens found that after these balls had sojourned in the stomach for some time their contents were dissolved. The same investigator also obtained the gastric juice of a dog, and observed that when placed in a warm locality it had the power of digesting meat.

Spallanzani, by experiments on fishes, reptiles and on himself, confirmed and extended the results previously arrived at by Reaumur and Stevens. We thus see that before the end of the last century the action of the gastric juice was tolerably well known, as well as its acid properties, and yet some persons doubted the accuracy of these results, stating that no acid fluid could be found in the stomach after death. They fell into error because they examined the stomachs of animals dying at a time when the stomach was not engaged in the process of digestion, and when therefore no gastric juice is to be found in it.

In 1800 Tiedeman and Gmelin carefully investigated the whole subject of digestion. They confirmed the observations of Reaumur, Stevens and Spallanzani, examined the chemical characters of the fluids secreted by the internal surface of the alimentary mucous membrane, and the changes effected by them on the food. Their researches embraced, indeed, the whole subject of digestion.

Then came some remarkable observations carried on by Dr. Beaumont, on a Canadian named Alexis St. Martin.

This man had, as the result of a gunshot wound, a permanent gastric fistula; that is to say, the cavity of his stomach communicated with the exterior by means of an opening situated on the left side of the chest two inches below the nipple. The borders of the opening into the stomach, which was of considerable size, had in healing united with the margins of the external wound, but the cavity of the stomach was separated from the exterior by a fold of mucous membrane which projected from the upper and back part of the opening, closing over it as a valve, but yet admitting of being pushed back.

Dr. Beaumont found that when the internal surface of the stomach was irritated mechanically, as by introducing the bulb of a thermometer into it, or when food entered the stomach, the mucous membrane became turgid, *i.e.* congested, and droplets of the acid gastric juice, began to ooze from its surface and trickle down. Introducing an elastic tube into the stomach he was enabled to draw off considerable quantities of gastric juice, and to cause it to act outside of the body, under varying conditions, upon the various alimentary substances. He had the opportunity of observing the influence of the bodily health, and of improper supply of food and drink (*e.g.* as intemperance), upon the aspect of, and secretion from, the gastric mucous membrane. He also made elaborate observations on the digestibility of various aliments, or rather on the rate with which various substances are converted into chyme.

Physical and Chemical Characters of the Gastric Juice.

Pure gastric juice is a thin, usually colourless though sometimes, as in the dog, yellowish liquid, possessed of a very acid reaction, and of a faintly acid mawkish taste, and of a peculiar though not easily defined odour.

It has a specific gravity, which varies between 1001 and 1010, the specific gravity varying in the same animal with varying conditions of the secretion.

When boiled, the gastric juice is not coagulable, but

ceases to be active. When cooled to 0° C. the gastric juice of warm-blooded animals ceases to exert its peculiar digestive powers.

The gastric juice of man contains less than 1 per cent. of solid matters, of which about two-thirds are organic, and one-third mineral.

The gastric juice may be kept for weeks and months without exhibiting any signs of putridity, and retaining its proteolytic activity. It possesses considerable antiseptic properties, as may be observed by moistening slightly putrid meat with the juice. This property has been ascribed to the free acid which it contains.

Its Essential Constituents.

The essential physiological attribute of the gastric juice is the power of breaking down and dissolving a large part of the solid proteid aliments, and ultimately converting them into *peptones*. This power depends upon the co-existence in the juice, of a ferment termed Pepsin and an acid which has been shown to be either free Hydrochloric acid or a more complex conjugated acid formed by the union of hydrochloric acid with an organic body, which, however, if it exists, is readily dissociated with the evolution of hydrochloric acid. Neither pepsin nor hydrochloric acid are active alone, but a mixture of the two bodies, in the presence of a proper quantity of water and at a suitable temperature, act essentially as the normal gastric juice. Whilst the enzyme pepsin is absolutely indispensable, the acid may be replaced by other acids, and yet proper digestion will take place.

Besides the proteolytic ferment pepsin, the gastric juice contains a *milk-curdling* ferment, which we may term the *Rennet ferment*. Neither pepsin nor the rennet ferment have yet been isolated as pure chemical bodies, but our knowledge of their properties is derived from a study of solutions which contain them in a state of more or less purity.

Besides the ferments we have mentioned, the gastric juice contains alkaline chlorides, earthy phosphates, and iron. No experiments have been made to determine the presence or nature of any gases which it may hold in solution or feeble combination.

Before considering in detail some of the facts which are known in reference to the ferments and the acid of the gastric juice and their relation to the process of digestion, let me draw your attention to a table exhibiting the composition of the gastric juice of the dog:

COMPOSITION OF THE GASTRIC JUICE OF THE DOG [illegible] WITHOUT ADMIXTURE WITH SALIVA [illegible] ANALYSES BY C. SCHMIDT.

Water in 1000 parts	[illegible]
Organic matters (including peptones, pepsin, mucin)	[illegible]
Free HCl	[illegible]
NaCl	[illegible]
KCl	[illegible]
NH_4Cl	[illegible]
$CaCl_2$	[illegible]
$Ca_3(PO_4)_2$	[illegible]
$Mg_3(PO_4)_2$	[illegible]
$FePO_4$	[illegible]

Nature of the Acid of the Gastric Juice.

Some of the first chemists who investigated the nature of the acid of the gastric juice asserted that this was free hydrochloric acid, basing their conclusion upon the fact that when the gastric juice is distilled, free hydrochloric acid is given off from it. It was pointed out, however, that the acid obtained in this experiment might be the product of the action of some organic acid, such as lactic acid, upon an alkaline chloride.

The matter was well-nigh settled many years ago by C. Schmidt, when he pointed out that the gastric juice contains chlorine in greater amount than could exist in combination with the whole of the mineral bases present in the juice.

These results of Schmidt's have been confirmed by

Richet. There are, however, facts of another kind which support this view.

Mineral acids in general behave towards certain organic colouring matters in a different manner from organic acids. As a type of an organic colouring matter whose behaviour in presence of these two classes of acids is very characteristic, I shall cite one which is used as a dye and which is known as O O–Tropaeoline. I have an alcoholic solution of this substance, which, as you observe, presents the appearance of a brownish-yellow liquid. When I add a few drops to this very weak solution of hydrochloric acid, you observe the immediate development of a beautiful pink colour, whilst when I add a similar quantity to solutions containing much larger quantities of acetic acid or lactic acid, no such reaction is developed.

This and many other similar reactions bear out strongly the view that the acid of the gastric juice is a mineral acid —a view which is likewise supported by the fact that when the gastric juice is shaken up with ether, this fluid dissolves but infinitesimal traces of acid. Were the acid a free organic acid a different result would certainly be observed.

A view has been propounded within a comparatively recent time by M. Charles Richet, that the acid of the gastric juice is not free hydrochloric acid, but a conjugated acid or acid salt, in which hydrochloric acid is linked to an organic base, probably to *Leucine*.

Shortly after M. Richet's results were published, certain yet unpublished experiments made, at my request, and under my direction by one of my pupils (Dr. Haslam) convinced me that this view could not be held, as a solution containing hydrochlorate of leucine and pepsine possesses no power of digesting proteids.

Pepsin.

I have already referred again and again to the fact that the chief ferment of the gastric juice is a body called *Pepsin*, concerning whose action we know many facts,

though we have not succeeded in isolating it in a state of purity.

If we place the mucous membrane of the stomach of a recently killed animal, say of a pig, in glycerin for some days or weeks, the glycerin extracts the ferment, so that on mixing some of the solution with water and dilute hydrochloric acid, a fluid is obtained which possesses the essential property of the gastric juice. Other solvents, as, for instance, weak alcohol or sherry wine, likewise dissolve pepsin.

I have not time to describe to you the various methods which have been followed with the object of separating the pure ferment from the gastric juice and from the stomach. None of these methods have yielded a definite body. The most satisfactory has, however, furnished a product which enables us to say that pepsin is a proteolytic ferment of extraordinary activity, and that it does not belong to the group of albuminous or proteid bodies.

Artificial Gastric Juice and Artificial Digestion.

I have already told you that, in general, the glands which elaborate or prepare the digestive juices contain within themselves stores of the ferments characteristic of their secretions, or of bodies which are immediate precursors of the ferments—so-called *Zymogens.*

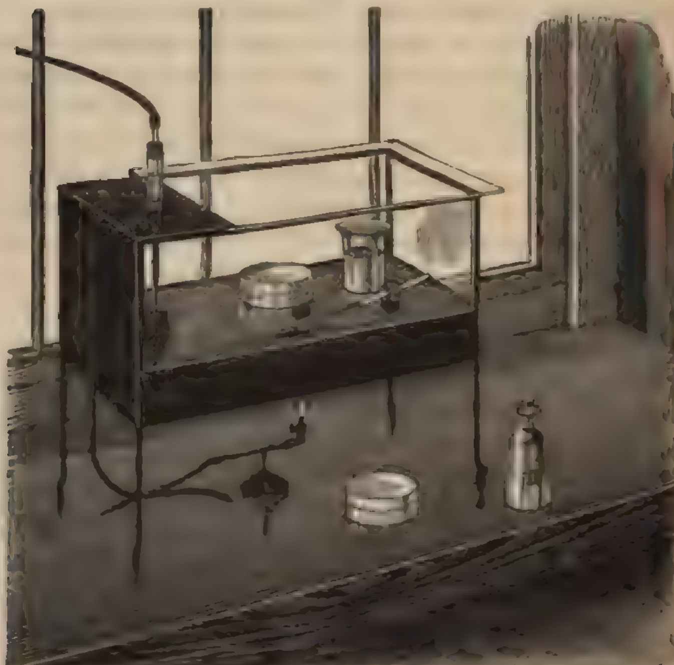
The glands of the mucous membrane of the stomach bear out these statements in a striking manner, as is proved by the fact just referred to, that glycerin or weak alcohol can dissolve pepsin from the mucous membrane.

When we place the mucous membrane of the stomach in water containing dilute hydrochloric acid and then raise the temperature of the mixture to the temperature of the mammalian body, the mucous membrane soon dissolves almost completely, and we obtain a liquid to which we give the name of *artificial gastric juice,* which will digest with ease in the same manner as the natural gastric juice. The acid to be employed in such experiments should contain

between 0·1 and 0·2 per cent of pure hydrochloric acid. (HCl).

Artificial digestions are usually conducted in water baths, or closets heated by hot water, so-called *Incubators*, provided with arrangements whereby a nearly constant temperature is maintained. Such an incubater is shown in Fig. 18.

Fig. 18.



AN INCUBATOR, OR CHAMBER SUITABLE FOR ARTIFICIAL DIGESTION.

The lower part of the chamber is filled with water. The supply of gas to the jet below is kept nearly constant by means of Page's mercurial regulator (Schafer's *Practical Histology*).

With the aid of such an apparatus we may experiment satisfactorily. I have here three beakers, and into one of these I place some water containing 0·2 per cent of hydrochloric acid; in a second, water to which I have added

some glycerin-solution of pepsin; in a third a mixture of acidified water and pepsin.

The three beakers I place in the incubator and into each I now drop a fragment of well washed blood fibrin. If we examine the beakers in the space of an hour, we shall find that the fibrin placed in the first beaker (containing dilute HCl) has swelled and become exceedingly transparent; that the fibrin placed in the second beaker (containing pepsin) appears unaltered; whilst the fibrin placed in a mixture of acid and pepsin has completely dissolved.

Without pepsin, it is impossible to obtain an artificial gastric juice. Is the hydrochloric acid equally indispensable, or may it be replaced by some other acid? The answer is that whilst hydrochloric acid acts most efficiently, other acids may, in combination with pepsin and water, enable the ferment to act. An acid *reaction* is, however, not sufficient to allow pepsin to digest proteids; the acid reaction must be due to a *free* acid.

If we boil our artificial gastric juice, we find that it at once loses its activity, in consequence of the pepsin, like all other animal ferments, being destroyed by so high a temperature. Many powerful chemical agents which precipitate or decompose pepsin exert a similar destructive influence upon the digestive activity of artificial gastric juice.

Peptones, the ultimate Products of the Action of Gastric Juice on Proteids.

Gastric juice, natural or artificial, exerts no action upon starches, sugars, or fats. Its digestive power is limited to its action on the proteid or albuminous substances, represented by such bodies as egg albumin, blood albumin, myosin (the chief albuminous constituents of flesh), casein, &c., and upon the so-called albuminoid bodies, which are very closely related to the last, and which are represented chiefly by collagen and gelatin.

Under the influence of the pepsin and acid of the gastric

juice, the albuminous substances, whether originally soluble or not, are *ultimately* converted into highly soluble bodies called *Peptones*, though many intermediate products are formed, to some of which I shall refer when pointing out to you the special characteristics of the pancreatic digestion of proteids.

The Characters of Peptones.

Peptones, like the bodies from which they are divided, are proteids, or at least are most closely connected with the proteids. By ultimate organic analysis they are found to have the same elementary composition as the bodies from which they are obtained.

They possess, however, certain properties which distinguish them from all other proteids.

In the first place, the peptones are *exceedingly* soluble in water, and in this respect contrast with all other albuminous substances which are soluble in water (save hemi-albumose).

In the second place, their watery solutions are not coagulated by heat, nor by the addition of any of the mineral acids, nor by neutralizing their solution if acid or alkaline.

Particularly, they are not precipitated by acetic acid and ferro-cyanide of potassium, which induces the precipitation of any other proteids in solution.

They are precipitated, however, by solution of tannic acid, and by solutions of phospho-molybdates.

When a solution of peptones is treated with a drop of a very weak solution of cupric sulphate and then caustic soda is added, a very pretty pink or rose colour is developed, whilst with other proteids, a violet colour is obtained. This reaction is, however, shared by one of intermediate products, to which we give the name of Hemi-Albumose.

The one property of great physiological importance which peptones possess is, however, that of *diffusing*

through animal membranes more readily than any other proteids. You remember that Graham pointed out that we may subdivide substances which are soluble in water into two groups, according to their power of diffusing through animal and vegetable membranes. If, for instance, I take a certain length of the empty intestine of an animal, and tie one end of it, I obtain a tube with walls composed of an animal membrane. Into this tube I pour a solution containing gelatin and common salt dissolved in water. Having introduced the solution, I apply a ligature to the tube a few inches above the level of the liquid, and hang the half-filled membranous tube in a jar holding distilled water. In a few hours I shall apply two tests to two different portions of the water. A solution of nitrate of silver will throw down a dense white precipitate of chloride of silver insoluble in nitric acid, showing that much common salt has made its way from the inside of the intestine, through its membranous walls, into the distilled water. To another portion of the water I shall add a solution of tannic acid, which possesses, as I now show you, the power of producing dense precipitates when added to solutions of gelatin. I shall find, however, that no gelatin will have diffused.

Graham called the bodies which are highly diffusible, "*Crystalloids*," for amongst the most highly diffusible bodies are many crystalline bodies: whilst he gave the name of "*Colloids*" to the bodies which like glue have little or no power of diffusing. Physiological chemistry teaches us that a body may be capable of crystallizing with ease, and yet be a colloid—such is the case with the beautiful crystalline Oxy-Hæmoglobin, the blood colouring matter,—and also, that bodies which have the closest relationship with, and which share, many of the properties of typical colloids, may be somewhat diffusible. Such are the peptones which we are now considering. It is true that their power of diffusing through the so-called "*parchment paper*" ordinarily employed in making the "dialysers" used in these experiments, is but small; they have, however, a much

greater power of making their way through animal membranes.

By the action of the gastric juice, then, or of pepsin and hydrochloric acid, acting upon proteids, soluble or insoluble, under favourable conditions of temperature, there are ultimately produced highly soluble bodies—the *peptones*, which being diffusible, may pass through the walls of lymphatics and blood-vessels and thus enter the blood.

These peptones are, doubtless, bodies of simpler molecular weight than the albuminous substances which yield them, and their production is due to a splitting up of a complex into simpler molecules. It is, however, unquestionable, that from the peptones absorbed from the alimentary canal, the more complex proteid molecules again arise, by synthetic processes whose exact seat is not known. Of the fact, however, we are certain, seeing that we may for long periods substitute peptones for native proteids in the diet of an animal, without any perceptible difference in the nutritive condition of the creature.

The Milk-Curdling or Rennet-Ferment of the Stomach.

It has long been known that the mucous membrane of the fourth or true stomach of the calf possesses the property of curdling milk, and various preparations of this mucous membrane have, under the name of "rennet," been employed to coagulate casein in the manufacture of cheese. It has also long been known that the gastric juice curdles milk; this action has been ascribed by some to pepsin, and by others with greater justice to the free acid of the gastric juice.

It was, however, first shown by Heintz, that the mucous membrane of the stomach possesses the property of curdling milk when the reaction is neutral, and even alkaline. The recent researches of Hammarsten have demonstrated that the milk-curdling property depends upon the presence of an enzyme of which the zymogen is

often, though not invariably, present in the gastric mucous membrane.

The mucous membrane of the stomach of the calf and of the sheep always contains *ready-formed* milk-curdling ferment which can be extracted from it by the action of water and other solvents to be mentioned hereafter; most frequently none can be extracted by water from the mucous membrane of the stomach of other mammals or of birds, and it is scarcely ever present in that of fishes.

Although the free ferment removable by water is rarely found, Hammarsten has shown *that the gastric mucous membrane of all animals, without exception, in which it has been investigated, contains a body which is not the milk-curdling ferment, but from which the milk-curdling ferment is quickly liberated on the addition of an acid.*

Hammarsten has found that the mucous membrane of the fundus is very much richer in the milk-curdling ferment and its zymogen than that of the pylorus.

Although the mucous membrane of the stomach of the calf and of the sheep always yields to water having a neutral reaction a sufficient quantity of milk-curdling ferment to demonstrate its peculiar properties, much more powerfully-acting solutions are obtained by the aid of dilute acids, as follows:—The mucous membrane of the stomach, preferably of a calf, is digested for twenty-four hours, at ordinary temperatures, in 150—200 c.c. of very dilute hydrochloric acid, containing from 0·1 to 0·2 per cent. of HCl. The liquid is then filtered and carefully neutralized. Twenty-five c.c. of fresh milk are then heated to 38° C., and treated with 1 c.c. of the neutralized liquid. Curdling is induced within a period of two minutes; this occurs even if the milk have been rendered faintly alkaline by caustic soda; the alkaline reaction persists after curdling. A glycerin-extract of the stomach of the calf may be used, as Hammarsten first showed, instead of the solution prepared as stated above; such a glycerin-extract can be preserved permanently, and is very active. Erlenmeyer has shown that a saturated aqueous solution of salicylic acid extracts

the milk-curdling ferment very perfectly from the stomach of the calf; from the solution the ferment mixed with other matters can be precipitated by alcohol. The precipitate thus obtained is soluble, in great part, in water, and the solution is active.

The ferment acts upon casein in neutral, acid, and feebly alkaline solutions, though an alkaline reaction diminishes, and, if marked, prevents curdling. The process of curdling is most rapidly brought about by solutions which have an acid reaction, which must not, however, depend upon a quantity of acid sufficiently large to precipitate, by itself, the casein.

The products of the action of the curdling ferment upon casein is different from the product of the action of acids; in the former case cheese is precipitated, in the latter casein.

The milk-curdling ferment does not convert milk-sugar into lactic acid.

Hammarsten precipitated a glycerin-extract of calf's stomach with alcohol, and dissolved the precipitate in water. The amount of dissolved matter was then determined, and also its power of coagulating casein. Assuming all the dissolved substance to consist of pure ferment, it would curdle from 400,000 to 800,000 times its weight of casein.

THE PROCESS OF DIGESTION IN THE LIVING STOMACH.

Having now spoken of the chemical composition of the gastric juice, the character of its separate constituents, and the action which they exert upon the particular class of proximate principles which are acted upon in the stomach, it remains to consider the actual process of digestion as it occurs in the living organ, and in doing so we shall be brought face to face with certain questions which have not been discussed in the preceding sections. Although experiments on artificial digestion teach us the nature of

the process which occurs in the stomach, we cannot pretend that such experiments will furnish us with data which will apply exactly to the stomach, for in this organ we have conditions which are very different from those which exist *in vitro.* In the stomach we have not an ordinary receptacle into which artificial gastric juice is poured so as to be mixed with food, but a receptacle kept constantly at a temperature most favourable to digestion, and provided with an arrangement for continually mixing the food to be dissolved with the solvent juice; a receptacle, too, in which absorption of water holding certain substances in solution is continually going on, and secretion of the pepsin and acid needed to carry on the digestive process; a receptacle from which, at a certain period of digestion, the more finely subdivided matter is gradually drawn off, leaving the grosser masses to be further subjected to the combined influence of mechanical movements and the solvent action of gastric juice. But for the continual removal by absorption of the peptones, which result from gastric digestion, the process would, as experiments on artificial digestion conclusively prove, quickly come to an end, only to recommence on further dilution of the liquid.

General Sketch of Digestion in the Living Stomach.

When food is introduced into the living stomach, the mucous membrane which was previously pallid becomes injected; droplets of liquid commence to exude from the open mouths of the gastric glands, and, uniting, form a stream of gastric juice. At the same time the organ contracts around the mass which it contains, and complex movements occur which cause "not only a constant disturbance or churning of the contents of the organ, but compel them at the same time, to revolve around the interior from point to point and from one extremity to the other."

"When food first enters the stomach the movements are

feeble and slight, but as digestion goes on they become more and more vigorous, giving rise to a sort of churning within the stomach, the food travelling from the cardiac orifice along the greater curvature to the pylorus, and returning by the lesser curvature, while at the same time subsidiary currents tend to carry the food which has been passing close to the mucous membrane towards the middle of the stomach, and *vice versâ*."

"While these revolutions of the contents of the stomach are progressing, the trituration or agitation is also going on. There is a perfect admixture of the whole ingesta, during the period of alimentation and chymification. There is nothing of the distinct lines of separation between old and new food, and peculiar central or peripheral situation of crude, as distinguished from chymified aliment, said to have been observed by Philip, Magendie, and others in their experiments on dogs and rabbits, to be seen in the human stomach; at least in that of the subject of these experiments. The whole contents of the stomach, until chymification be nearly complete, exhibit a heterogeneous mass of solids and fluids; hard and soft; coarse and fine; crude and chymified; all intimately mixed, and circulating promiscuously through the gastric cavity, like the mixed contents of a closed vessel, gently agitated or turned in the hand." . . . . "As the food becomes more and more changed from its crude to its chymified state, the acidity of the gastric fluids is considerably increased, and the general contractile force of the muscles of the stomach is augmented in every direction; giving the contained fluids an impulse towards the pylorus. It is probable that from the very commencement of chymification—from the time that food is received into the stomach until that organ becomes empty—portions of chyme are constantly passing into the duodenum through the pyloric orifice, as the mass is presented at each successive revolution. I infer this from the fact that the volume is constantly decreasing. This decrease of volume, however, is slow at first; but is rapidly accelerated towards the conclusion of digestion, when the

whole mass becomes more or less chymified. This accelerated expulsion appears to be effected by a peculiar action of the transverse muscles, or rather of the *transverse band* . . . . . situated near the commencement of the more conical shaped part of the pyloric extremity, three or four inches from the smaller end. In attempting to pass a long glass thermometer tube through the aperture into the pyloric portion of the stomach, during the latter stages of digestion, a forcible contraction is first perceived at this point, and the bulb is stopped. In a short time, there is a gentle relaxation, when the bulb passes without difficulty, and appears to be drawn, quite forcibly, for three or four inches, towards the pyloric end. It is then released, and forced back, or suffered to rise again ; at the same time giving to the tube a circular, or rather spiral motion, and frequently revolving it completely over. These motions are distinctly indicated, and strongly felt, in holding the end of the tube between the thumb and finger ; and it requires a pretty forcible grasp to prevent it from slipping from the hand, and being drawn suddenly down to the pyloric extremity. When the tube is left to its own direction, at these periods of contraction, it is drawn in, nearly its whole length, to the depth of ten inches : and when drawn back, requires considerable force, and gives to the fingers the sensation of a strong *suction*-power, like drawing the piston from an exhausted tube. . . . . . These peculiar motions and contractions continue until the stomach is perfectly empty and not a particle of the food or chyme remains ; when all becomes quiescent again. . . . The peculiar contractions and relaxations, mentioned above, succeed each other at regular intervals of from two to four or five minutes. Simultaneously with the contractions there is a general shortening of the fibres of the stomach. This organ contracts upon itself in every direction ; and its contents are compressed with much force. . . . . . During the intervals of relaxation, the rugae perform their vermicular actions, the undulatory motions of the fluids continue, and the alimentary and chymous masses appear,

revolving as before, promiscuously mixed, through the splenic and cardiac portions."*

In quoting *verbatim* considerable portions of Dr. Beaumont's vivid and unique observations on his patient St. Martin, I do so because the description will give you some idea of the intensity of the mechanical movements which aid the chemical action of the gastric juice so efficiently as to enable the stomach to effect digestive operations which, in point of magnitude, cannot be imitated in the laboratory.

The term Chyme (*χυμος* juice) is generally applied to the pulpy semi-fluid matter resulting from the action of the gastric juice on the mixed aliments, and the term Chymification to the process which results in the formation of chyme.

When much fluid is introduced into the stomach, absorption at once commences actively. This is proved by the fact, amongst others, that almost instantly the sensation of thirst, when that exists, which depends primarily upon a diminution of the water of the blood, diminishes. At the same time, doubtless, the absorption of some diffusible substances occurs, as is proved by the fact that a few minutes after the introduction of potassium iodide into the stomach, the salt is separated by the kidneys and other glands. The extent to which the process of absorption proceeds in the stomach cannot, however, be exactly stated.

The constituents which are chemically acted upon by the gastric juice in the stomach are firstly the proteids, and secondly the *albuminoid* bodies, such as collagen and gelatin, chondrigen and chondrin.

The other groups of organic food constituents, viz. fats and carbohydrates, are very slightly acted upon by the gastric juice itself; in considering this slight action of the gastric juice we shall have to enquire to what extent the

* Beaumont, 'Experiments and Observations on the Gastric Juice.' Edinburgh edition, 1838, p. 101.

amylolytic action of the saliva upon the alimentary starch is allowed to proceed in the presence of the acid juices of the stomach.

The Changes which Adipose Tissue undergoes in the Stomach.

Until lately the majority of authorities have held that the fatty constituents of the food undergo no change in the stomach, although their subsequent digestion in the small intestine is promoted by the solution of the walls of the fat cells, which occurs in the stomach, and which liberates their fatty contents.

It was stated by Dr. Marcet, however, that a certain decomposition of the neutral fats takes place in the stomach, and in a recent research Dr. Cash has found that when dogs are fed upon perfectly neutral fats, fatty acids are liberated in small quantities, and that when the mucous membrane of the stomach is digested with neutral fats, in the presence of hydrochloric acid, fatty acids are likewise liberated. This setting free of traces of fatty acids will doubtless aid the subsequent emulsionizing of the fats by the bile and pancreatic juice.

The Changes which Starch undergoes in the Stomach.

In discussing the changes which starch undergoes in the stomach, we have to consider, firstly, whether the gastric juice possesses by itself any action upon starch, and secondly to what extent the action of the saliva upon starch continues in the stomach.

The saliva of many animals, *e.g.* the dog, is devoid of diastatic properties. If a dog be fed upon a meal of boiled starch and killed during digestion whilst the stomach still contains food, mere traces of sugar are found, but the contents contain both soluble starch and erythrodextrin (Brücke). Unboiled starch is unacted upon.

The contents of the stomach of man fed upon a diet containing boiled starch always contain considerable quantities of sugar, and the question arises, Was the sugar produced by the momentary action of saliva upon starch during mastication and deglutition, or did the conversion of sugar under the influence of saliva continue in the stomach? In endeavouring to solve this question, we have to bear in mind, firstly, that diastatic ferments do exert their action upon starch in a fluid of *feebly* acid reaction, and, secondly, that that action is arrested so soon as the reaction becomes *strongly* acid. It would therefore appear most likely that in the early stages of gastric digestion, before the admixture with gastric juice is complete and when the acidity of the gastric juice is comparatively feeble, the diastatic action of the saliva proceeds in the stomach, whereas soon after, when the acid reaction has attained a certain amount, diastatic action diminishes or even ceases altogether.

The statements of various authors concerning the influence of an acid reaction upon the diastatic action of the salivary ferment differ remarkably. Thus Brücke asserts that in a solution containing 0·5 of HCl per 1000, the conversion of starch into sugar goes on, whilst when the quantity reaches 1 per 1000, no action on starch occurs Hammarsten found that the diastatic action ceased when the quantity of hydrochloric acid amounted to from 0·05—0·25 per cent. Langley observed that when saliva is digested with HCl of from 0·2 to 0·04 per cent. for times varying from twenty-four to seven hours the ferment was destroyed. On the other hand, Richet asserts that saliva exerts a more powerful action on starch in the presence of 2 parts per 1000 of hydrochloric acid, than when the reaction is neutral or feebly alkaline, and Defresne contends that diastatic action goes on unimpeded by the gastric juice.

Closely connected with the question just discussed is that whether the diastatic ferment is destroyed or not in the stomach. Upon this matter the statements of authors differ very greatly. Thus it is said by Cohnheim, that the diastatic ferment is not destroyed when submitted to

artificial digestion with pepsin and hydrochloric acid for many hours, for on neutralising the liquid it was found to possess diastatic powers. Schiff makes the same statement; and more recently Defresne has repeated it. Roberts, on the other hand, asserts that the diastatic power of the saliva is quickly and permanently abolished both by an artificial digestive fluid and by filtered gastric juice obtained from the human stomach. I have convinced myself of the accuracy of this statement, which is further confirmed by Langley.

Changes in the Acidity of the Contents of the Stomach during Digestion.

It has been already said that the acidity of the contents of the stomach increases as digestion proceeds, and attention must now be directed to variations which occur simultaneously in the nature of the free acid.

It has been shown in a previous section that the acid reaction of the gastric juice is due to the presence of free hydrochloric acid, though Richet maintains, of hydrochloric acid in combination with an organic body, such as leucine. V. der Velden asserts that in the first stages of digestion in the human stomach no free hydrochloric acid is present, as long as two hours elapsing after a full meal, such as dinner, before the acid appears.

The gastric juice behaves, it was shown, when shaken with ether, as an aqueous solution containing a mineral acid.

The pure gastric juice of man has an acidity which, according to Richet's observations, corresponds to 1·3 parts by weight of HCl in 1000.

When digestion is proceeding, however, the acidity increases somewhat. However large the quantity of liquid in the stomach, it is found to have an acidity which on an average (according to Richet) corresponds to 1·7 parts of HCl per 1000, though it may, especially at the end of digestion, exceed this figure somewhat. After the in-

gestion of acids or of alkalies, the normal acidity is soon re-established.

Richet has found that in the advanced stages of digestion the acidity of the contents of the stomach no longer depends solely on a mineral acid, but that considerable quantities of acids soluble in ether are present. These acids are in part produced by the decomposition of salts of organic acids present in the ingested food, but, according to Richet, in no small degree they result from acid fermentations which occur in the stomach. Thus in the digestion of milk, according to Richet, there is set up, as a normal process, an acid fermentation which leads to the development of large quantities of lactic acid. The feebler the normal acidity of the gastric juice, the greater the quantity of the organic acids resulting from fermentative changes. There can be no doubt that the acids thus set free reinforce the normal acid and co-operate in the process of digestion.

Duration of the Digestive Process in the Stomach.

The digestive process varies in duration in different animals, and in the same animal according to the nature of the food, its state of division, &c. Dr. Beaumont found the duration of the gastric digestive process in Alexis St. Martin, to be between three to five hours, and Richet remarks, as the result of his observations on his patient Marcelin, that the digestive process does not appear to extend beyond four or five hours.

In dogs and other carnivorous animals which are in the habit of "bolting" large masses of meat, undigested masses are found in the stomach eight or ten hours after a meal, and often longer.

The Final Products of Digestion which leave the Stomach. The Chyme.

As a result of the combined influence of the gastric juice, of the movements of the stomach and the high temperature

of the organ, the solid alimentary matters are reduced to a pulpy or semi-fluid condition, and it is in this state that they are allowed to escape through the pylorus into the duodenum.

During the digestive process large quantities of proteids and of albuminoid bodies have been converted into peptones, of which doubtless a part—though we have no data on the subject—is absorbed by the gastric mucous membrane as soon as formed, whilst a part is held in solution in the liquid portion of the *chyme*. As a result of the action of the acid of the gastric juice, insoluble mineral salts, as *e.g.* bone-earth, are dissolved and doubtless are absorbed, as are also soluble salts, sugar, and large quantities of water.

The chyme, then, must contain chiefly the undigested or partially digested fragments of food, mixed with gastric juice holding products of digestion in solution.

Accordingly, we observe it to contain fragments of muscle, and individual muscular fibres splitting into fibrils, and tending to cleave into transverse discs. The fibrillar connective tissue has wholly or in great part disappeared, but yellow elastic tissue is found apparently quite intact; the same remark applies to cellulose and to the epidermal tissues of animals. If raw starch has been partaken of, the chyme is sure to contain unaltered starch grains.

Lastly, if adipose tissue or any fat was contained in the food, drops of liquid fat are found in the chyme. It has been observed by Richet that where the contents of the stomach contain much fat, this appears to be retained in the stomach until all other matters have been expelled.

The Non-Digestion of the Stomach by its own Juice.

The fact that the delicate mucous membrane of the living stomach is not digested by the gastric juice which it secretes, early attracted the attention of observers.

When animals or human beings are killed whilst the digestive process is actively proceeding, it not unfrequently happens that large portions of the stomach are softened and perforated ; the gastric juice then escaping may act upon adjacent organs, partially digesting them, as in a case which came under my notice, in which a part of the spleen had been pretty thoroughly digested, and the left half of the diaphragm had been perforated. The process proceeds most perfectly when the external conditions are such that the body cools slowly ; it affects particularly the fundus of the stomach.

John Hunter attempted to explain the non-solution of the living stomach by the gastric juice as due to its vital properties, which exempted it from an action which dead matter could not resist. But this explanation, besides being open to the objection of a *petitio principii*, is disproved by the fact that living tissues may, under certain circumstances, be digested by the stomach. Thus Claude Bernard found that the legs of a living frog which had been introduced through a fistula into the interior of the stomach of a dog underwent digestion though the animal was alive.

Claude Bernard explained the non-digestion of the gastric mucous membrane as due to its epithelial covering, which is continually being renewed, whilst Schiff believed that the layer of mucus which covers the internal surface of the stomach effectually protects it. The view of Claude Bernard is disproved by the fact that in cases where the continuity of the epithelial covering of the stomach is interrupted, as in gastric ulcer, digestion of the parts deprived of epithelium does not occur. Schiff's view is probably in part true. Scientific opinion has, however, inclined to favour the view of Dr. Pavy, that the non-digestion of the living stomach is connected with the circulation, through the blood-vessels of the mucous membrane, of alkaline blood, whence there is continually transuding alkaline plasma, which bathes the ultimate anatomical elements of the tissues. The acid gastric juice

which could penetrate to these having its acidity removed is naturally rendered inert. This view is supported by the fact that when certain of the arteries of the stomach are tied the areas supplied by them are liable to perforation by a process akin to that of *post-mortem* digestion.

LECTURE V.

THE STRUCTURE OF THE DUODENUM—THE BILE AND THE PART WHICH IT PLAYS IN DIGESTION—THE PANCREAS; ITS SITUATION AND STRUCTURE—THE FERMENTS OF THE PANCREAS AND PANCREATIC JUICE.

IN my last lecture I told you that at the beginning of gastric digestion the *pylorus*, or pyloric orifice of the stomach, is tightly closed, but as digestion proceeds it becomes more and more relaxed, so that whilst at first only the finer parts of the gastric contents can pass—in the form of pulpy chyme—afterwards the coarser parts, and even solid lumps of imperfectly digested aliment are permitted to escape into the duodenum.

The chyme when it leaves the stomach possesses a strong acid reaction. On entering the duodenum it encounters, however, the secretions of the glands of the duodenum, but especially the secretions of the liver and of the pancreatic juice, all of which possess an alkaline reaction, so that the acid reaction is soon lost.

Let me direct your attention to the diagrams to which I have before pointed, which exhibit the general arrangement of the organs of digestion (see Fig. 1, p. 39), as well as one (Fig. 19) in which we have the stomach and duodenum laid open, and the point of entrance of the various ducts exhibited.

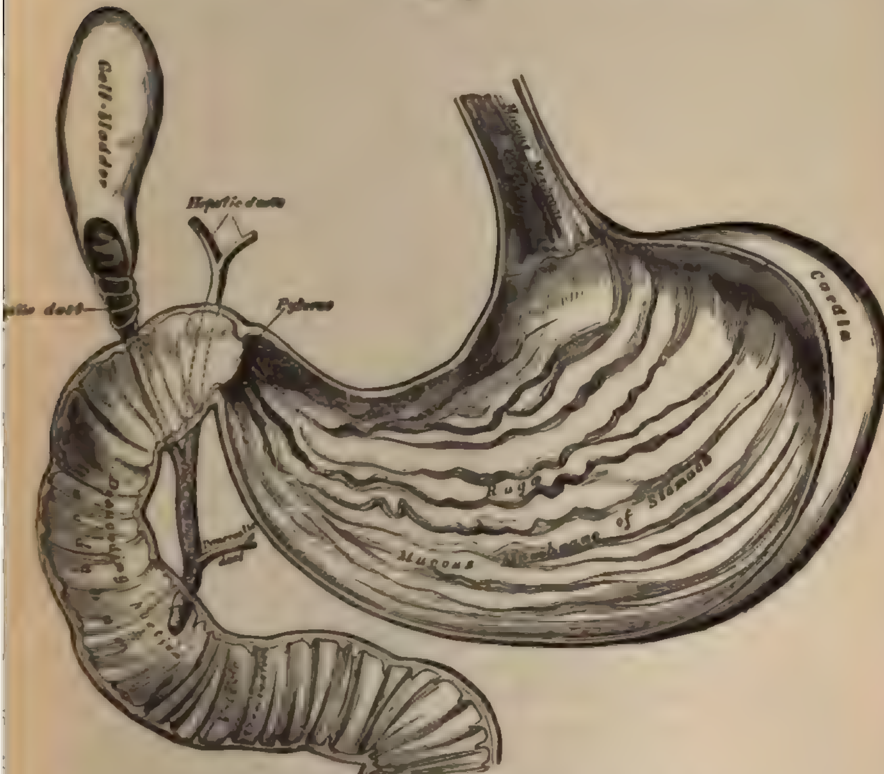
The Structure of the Duodenum.

Before speaking to you of the important chemical operations which are brought about by the digestive juices poured into the duodenum, let me, for a moment only, dwell upon

its structure, which I shall illustrate by a reference to a diagram, which I have had copied from Professor Turner's 'Introduction to Human Anatomy.' (See Fig. 20.)

Observe that the mucous membrane presents the projecting processes or *villi*, which are seen throughout the

FIG. 19.



THE INTERIOR OF THE STOMACH AND DUODENUM, WITH THE ENTRANCE INTO THE DUODENUM OF THE COMMON BILE DUCT AND THE PANCREATIC DUCT (GRAY'S ANATOMY).

small intestine, and to whose structure I shall again refer. At the base of these villi, and occupying the greater part of the thickness of the mucous membrane, are placed side by side a number of simple glands, like test tubes, which are

lined by a single layer of columnar epithelial cells. These are the so-called "Glands of Lieberkuhn." Glands of precisely similar structure are found in the mucous membrane throughout the course of the small intestine, and essentially the same kinds of glands also occur in the large intestine. The epithelium which lines them unquestionably has for one of its functions the secretion of a liquid containing some mucus, and to which I shall again refer, under the name of

FIG. 20.

VERTICAL SECTION THROUGH THE WALLS OF THE DUODENUM (TURNER).

Showing: V, intestinal villi; L, layer of glands of Lieberkühn: *m*, *m*, tunica muscularis mucosæ; S M, submucous coat; M, a schematic indication of a portion of the muscular coat: B, a gland of Brunner, situated in the submucous coat, with its duct *d*, running between glands of Lieberkuhn and opening on the surface of the mucous membrane.

"Intestinal juice." Beneath this layer of glands we observe (Fig. 20, *m m*) imperfectly delineated the layer of involuntary muscular fibres which is called the (tunica) *muscularis mucosae*, and to which I referred, as well as to other matters which I should wish you to remember, in my

second lecture (p. 41). Below this we observe the *sub-mucous* coat.

In this you will notice the lobes of an acinous gland, one of the Glands of Brunner, whose duct opens on the surface of the mucous membrane. The Glands of Brunner are peculiar to the duodenum: they have a structure which, according to Klein, is identical with that of the pyloric glands of the stomach, and they appear, like them, to form a small quantity of pepsin.

To some points in which the duodenum shares more or less the characters of the rest of the small intestines, I shall subsequently direct your attention.

The Bile and its Influence on Digestion.

The Bile is the secretion of the Liver, which is the largest of the glands of the body. At one time it was believed that the preparation of this fluid was the essential function of the liver. When we take into account the large size of the organ, which in adult human bodies has a weight which amounts to between one twenty-fourth and one-fortieth of that of the body, that its substance contains myriads of protoplasmic masses supplied in a peculiarly lavish manner with blood, we are not surprised to learn that modern research has established that whilst the liver is of all the organs of the body, the one in which chemical changes of the greatest magnitude have their seat, the secretion of bile represents but very imperfectly the activity of the organ.

This great gland secretes daily an amount of bile, which in man, probably amounts to between ten and twenty ounces, though the amount varies, as that of other secretions of the body, with many circumstances, and is particularly influenced by the food of the individual.

The colour of the bile of man and carnivorous animals is, when fresh, reddish brown, and is mainly due to the chief colouring matter termed *Bilirubin*. Its reaction is dis-

tinctly alkaline. The specific gravity of the bile is about 1020, and it probably contains, when freshly secreted, less than two per cent. of solids.

The solid matters of the bile present as their principal components: 1st. The colouring matters, of which the chief is the before-mentioned *Bilirubin*. This has the empirical formula $C_{16} H_{18} N_2 O_3$; it admits of being separated in the form of orange-coloured microscopic crystals, and is undoubtedly derived from the blood colouring matter, oxy-hæmoglobin, of which a certain amount undergoes destruction either in the spleen or liver, or in both of these organs, certain of the products of the decomposition being excreted in the bile. Bilirubin and all the allied bile-colouring matters, as, for instance, *Biliverdin*, which gives the green colour to the bile of herbivorous animals, exhibit the so-called Gmelin's Reaction, i.e., when treated with strong impure nitric acid, a play of colours is produced—green, blue, violet, and red being successively distinguished.

2nd. Sodium salts of the so-called bile-acids, viz., Glykocholic and Taurocholic acids.

The former of these acids has the formula $C_{26} H_{43} NO_6$; and the latter, which contains sulphur, $C_{26} H_{45} NO_7 S$. They are recognized in the bile by the so-called Pettenkofer's reaction, which consists in adding to a little bile on a white plate, a few drops of a watery solution of sugar, and afterwards some strong sulphuric acid, when a beautiful purple colour is produced.

The bile-acids are doubtless products of decomposition of proteid constituents in the liver.

3rd. A beautiful crystalline body termed Cholesterin, $C_{26} H_{43} O$, which is soluble in ether, and was formerly erroneously believed to be a fat. It is an abundant constituent of nerve-fibres, and is found in large quantities in the nerve-centres; whence it is probably removed in part by the blood and excreted by the bile.

4th. The viscid body called Mucin.

5th. Certain mineral salts.

The table to which I point indicates the composition of human bile according to the most recent analyses of Yeo and Herroun.

We have now to consider the uses of the bile in digestion, and these I may dismiss very briefly.

The bile in man and the majority of animals contains no ferment, and therefore exerts no specific action upon any of the organic food constituents. It would be a mistake, however, to believe that it plays no part in digestion. Coming in contact with the acid chyme as it enters the duodenum, it neutralises in part the free acid which it contains, and so tends to establish one of the conditions necessary to the proper progress of pancreatic digestion. This neutralisation is accompanied by the precipitation in part, at least, of intermediate products of the digestion of proteids, such as hemialbumose, and the precipitate thus occasioned doubtless carries down with it, mechanically, much of the pepsin which exists in the more fluid part of the chyme. It co-operates with the pancreatic juice in emulsionizing the fatty matters of the chyme, whilst it appears to possess the power of influencing the passage of finely divided fats through the mucous membrane. This function of the bile in facilitating the absorption of fats is one which must not be lost sight of and which is proved by many facts which I have not the time to bring before you, but which are quite sufficient to disprove the view of those who have spoken of the inutility of the bile in digestion.

Amongst the subsidiary functions of the bile in the alimentary canal appears that of modifying, in an unknown way, the processes of decomposition which occur in it, for in living creatures from whose intestinal canal bile is cut off, either by artifice or disease, a peculiarly putrid decomposition of the intestinal contents invariably occurs.

The secretion of the liver is one which unlike that of the gastric glands or of the pancreas is continuous, though its activity varies greatly. In man and a large number of animals the secretion is not, however, continually dis-

charged into the duodenum, but may be in part stored in the so-called gall-bladder.

We have seen that the bile possesses some uses in digestion, though it cannot be looked upon as occupying the first rank amongst digestive juices. It is a liquid which, though not without distinct functions, and therefore not to be compared to a simple excretion, such as that of the kidneys, yet is, in the main, an excretion. I am often in the habit of comparing it to the liquid refuse leaving a chemical manufactory, which, by its composition and amount, often conveys but a very imperfect idea of the nature and magnitude of the processes which are carried on in the factory.

To the principal functions of the liver, so far as they are known to us, I shall, in the last of this series of lectures, briefly call your attention.

The Pancreas and the Pancreatic Juice.

The Pancreas is a gland which secretes an alkaline juice, and which empties itself into the upper portion of the small intestine.

It exists in all air-breathing vertebrates—in mammals, birds, reptiles—and in many, though by no means in all, fishes.

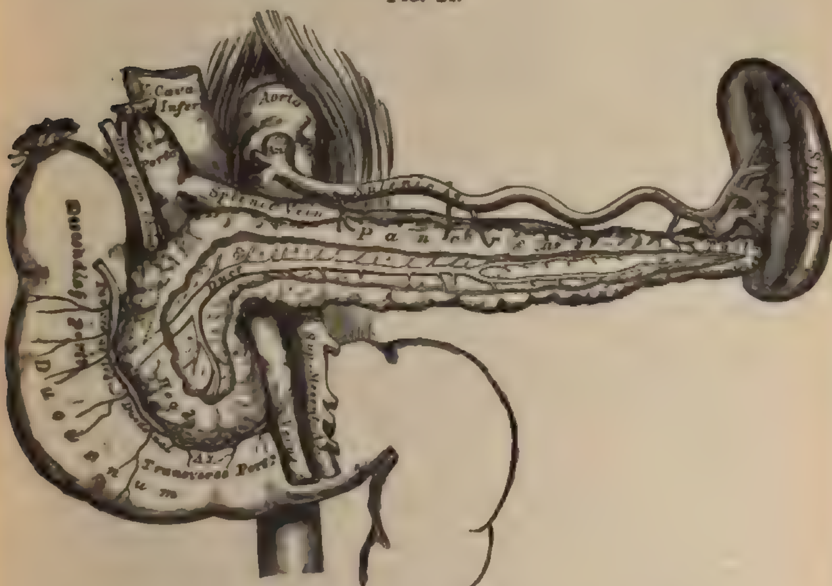
Although it has been usual to say that the pancreas does not exist in invertebrates, it would appear from the recent researches of Krukenberg and others that a glandular organ which is the physiological analogue of the pancreas is widely distributed throughout invertebrates.

The Pancreas is a long narrow gland of a yellow cream colour, which during life varies in tint, being pale when inactive, but turgid and roseate in hue whilst secretion is proceeding. In man the organ lies "across the posterior wall of the abdomen, behind the stomach, and opposite the first lumbar vertebra. Its larger end, the *head*, turned to the right, is embraced by the curvature of the duodenum, whilst its left or narrow extremity, the *tail*, reaches to a somewhat higher level, and is in contact with the spleen."

In the figure to which I now point, Fig. 21, you will see the duodenum detached from other parts of the alimentary canal, but with its relations to the gland which is chiefly to occupy our attention, viz., the Pancreas.

Observe running along this elongated gland, a tube, its duct, and follow the dotted lines, which indicate the entrance of the pancreatic duct into the duodenum. You will see that just before reaching the duodenum the pancreatic duct is joined by the so-called "*Ductus communis choledochus*," or common bile duct, which conveys the *bile* from the liver into the duodenum.

FIG. 21.



THE PANCREAS AND ITS RELATIONS TO THE DUODENUM AND SPLEEN. (GRAY'S ANATOMY.)

The normal arrangement is that there exist two pancreatic ducts. One, very much larger than the other, *the* pancreatic duct, properly so-called, or *Duct of Wirsung*,*

* Wirsung was an anatomist of the 17th century who first observed and delineated the pancreatic duct. He is said to have died by the

empties itself into the duodenum between three and four inches below the pylorus by an orifice common to it and to the common bile duct; the second, very small, *accessory* pancreatic duct, communicates with the first by one or more anastomosing branches, and usually has a separate opening into the duodenum. In most animals the chief duct of the pancreas opens into the intestine with, or very near to, the opening of the common bile duct. In some animals, however, as in some monkeys,* in the ox, the guinea-pig, and the rabbit, the principal duct empties itself below the orifice of the bile duct. In the last-named animal the arrangement has been particularly studied by Claude Bernard, who has shown that whilst the accessory duct usually opens by a common orifice with the bile duct, the principal duct empties into the intestines 35 centimeters below that point.†

Minute structure of the Pancreas.

The pancreas used to be described as a compound saccular or racemose gland. The observations of Latschenberger and Heidenhain have drawn attention to the fact, however, that the pancreas is more properly a compound tubular gland, i.e. if we follow its branching ducts we find them terminating in blind tubes, and not in sacculated recesses.

The gland possesses a capsule of connective tissue whence septa proceed inwards, which penetrate the organ and support its constituent lobes and lobules. The interlobular connective tissue supports the blood-vessels, the nerves, and the lymphatics of the gland.

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hands of an assassin in 1643, the same year in which he sent a copy of his engraving of the pancreatic duct to Riolan. (Claude Bernard, 'Leçons de Physiologie Expérimentale,' Vol. II. (1856), p. 171.)

* See Milne Edwards, 'Leçons sur la Physiologie et l'Anatomie Comparée' (1860), Vol. VI. p. 511.

† Claude Bernard, *op. cit.*, pp. 270 and 271.

The pancreas possesses, as has been said, in most animals, two, in some more than two excretory ducts. These ducts are lined by columnar epithelium, which lies upon a basement membrane. On the outer side of this basement membrane there is no inconsiderable amount of fibrillar connective tissue and some involuntary muscular fibres. With the excretory ducts there communicate the lobar ducts, these proceeding outwards lead to intralobular ducts, and these again to so-called *intermediary ducts* which communicate directly with the alveoli.

The epithelium lining lobar and intralobular ducts is composed of short columnar epithelium cells, each with an oval nucleus near the membrana propria on which the cells lie. The epithelium cells become shorter from the lobar towards the *intermediary ducts.* It is to be noted that the epithelial cells of the ducts of the pancreas do not exhibit the "rod-like fibres" (Klein) which are so clearly seen in the intralobular ducts of the salivary glands.

The intermediary ducts "are branched canals of various lengths with a small but distinct lumen; each consists of a membrana propria, a continuation of the same membrane of the intralobular duct, lined with a single layer of flattened clear cells more or less elongated, and each with a flattened oval nucleus" (Klein). In some cases, as in the pancreas of the rabbit, these tubes are very long, in others extremely short, the branches of the intralobular ducts appearing to pass almost into the alveoli.

The alveoli which open into the intermediary canals are more or less tortuous tubes composed of a delicate basement membrane which is covered on its inner side by the proper secreting cells which, as Heidenhain aptly remarks, possess specific peculiarities which make it impossible to mistake them for the cells of any other gland. These cells are sometimes described as columnar, but they are not as regular as typical columnar epithelium cells and present much more rounded outlines. The tube is so filled by these cells that no definite continuous lumen can be made out.

The appearances of the pancreatic cells differ greatly

according as the gland has been for many hours inactive or long secreting. We shall at present only describe the appearance of the cells of the pancreas of the fasting animal.

Each cell presents, in its fresh living condition, a clear *apparently* homogeneous *outer zone*, directed towards the basement membrane, and a granular *inner zone*. The clear outer zone is relatively small, only forming from one-eighth to one-sixth of the depth of the cell. Carmine stains the outer, clear zone easily, but scarcely at all the granular inner zone.

The outer zone which in the living cell appears homogeneous is not so in reality, as we learn by the action of perosmic acid, or by pretty prolonged maceration in solution of neutral ammonium chromate, which reveal the existence of longitudinal fibrillation.

At the junction of the outer and inner zone of the cells of the fasting pancreas is situated a spherical nucleus which is scarcely if at all visible in the living cell, but which is stained by carmine or logwood.

The pancreas in man receives branches from—1st, the hepatic artery; 2nd, the splenic artery; and 3rd, the superior mesenteric artery. The branches from these arteries form numerous anastomoses. A capillary network surrounds the ultimate acini, but by no means closely, so that often the secreting cells are at a considerable distance from the nearest capillaries.

The veins of the pancreas which run by the side of the arteries empty into the superior mesenteric and into the splenic veins, so that all the blood which leaves the organ has to pass through the liver.

General Phenomena of the Pancreatic Secretion.

The general phenomena of the secretion of pancreatic juice have been discovered by observing firstly and chiefly animals in which temporary fistulæ had been established, during the time which elapses before the functions of the

gland become, as a result of the operation, perverted; and, secondly, animals in which permanent fistulæ have been successfully established; as a rule, the fluid obtained from permanent fistulæ soon ceases to be normal.

So long as the condition is perfectly normal the following is the order of events:—

After a fast lasting twenty-four hours or more the pancreas ceases to secrete. Immediately after food has been taken, secretion commences, and the rate of secretion increases rapidly, reaching a maximum some time within the first three hours. The secretion then diminishes until a period which Heidenhain states as extending from the fifth to the seventh hour, when a rise occurs which lasts to the ninth or eleventh hours. The secretion then gradually sinks, until it absolutely ceases; at the seventeenth hour there is then a very scanty secretion; at the twenty-fourth hour all secretion has ceased. The fluid secreted in the early periods of digestion is very viscous, and soon gelatinizes on standing; it is highly coagulable. It contains from 6 to 10 per cent. of solid matters. As digestion progresses, the juice becomes less viscid, its coagulability diminishes, and its solid matters also become less; so that even in the physiological condition we may have a comparatively non-viscid and sparingly coagulable juice.

But in most cases when a pancreatic fistula has been established matters do not continue as above, and the departure from normality is increased, firstly by the secretion becoming continuous; secondly, by its becoming abundant and non-viscous, as well as by another most important character. The normal juice possesses the power, firstly, of digesting proteids; secondly, of converting starch into dextrins and maltose; thirdly, of emulsionising and decomposing the neutral fats. Now the non-viscous, abundant, secretion obtained from the majority of cases of permanent fistulæ only possesses the second and third of these properties; it is, that is to say, destitute of, or at least very poor in, the proteolytic ferment.

Though the close dependence of the secretion of pan-

creatic juice upon the various stages of the digestive process must clearly depend upon nervous control, our knowledge of the nervous mechanism is not as complete as might be wished.

From the analogy to the salivary glands Heidenhain thinks it likely that in the pancreas as in the salivary glands there exists two classes of secretory nerves which influence its activity, viz., truly *secretory*, i.e., which govern the separation of water and salts by the gland, and *trophic*, which by influencing the exchanges of matter in the secreting cells, influence the passage of solid constituents into the secretion.

Bernard pointed out that the fasting pancreas is pale, the active pancreas firm and turgid, and Kühne and Lea have observed the circulatory changes going on in the pancreas of the living rabbit, which are referred to in the subjoined paragraph.

Changes in the appearances of the secretory cells of the Pancreas which accompany secretion. Concomitant vascular changes.

Our knowledge of the remarkable changes which the secretory cells of the pancreas undergo during digestion is derived first of all from the researches of Heidenhain, which have been confirmed by the remarkable observations made by Kühne and Lea, who were able to watch the actual process of pancreatic secretion in the case of the transparent pancreas of young rabbits, which was drawn through a small wound in the abdominal wall, and examined under the microscope, special arrangements being employed which prevented evaporation and cooling. The following is a short summary of the researches of Heidenhain and Kuhne and Lea, which I quote from Professor Michael Foster's admirable work on Physiology :—

"We learn from the researches of Heidenhain that each secreting cell of a pancreas of an animal (dog) which has been fasting for 30 hours or more consists of two zones : an

inner zone, next to the lumen of the alveolus, which is studded with fine granules, and a smaller outer zone, which is homogeneous or marked with delicate striæ. Carmine stains the outer zone easily, the inner zone with difficulty. The nucleus, more or less irregular in shape, is placed partly in the one and partly in the other zone. When, however, the pancreas of an animal in full digestion (about six hours after food and onwards) is examined, the outer homogeneous zone is found to be much wider, the granular inner zone being correspondingly narrower, and in some cases actually disappearing. The whole cell is smaller, and, owing to the relatively larger size of the outer zones, stains well. The nucleus is spherical and well formed. If the pancreas be examined at the end of digestion, when its activity has once more ceased, and it has entered into a state of rest, the outer zone is again found to be narrow, the granular inner zone occupying the greater part of the cell, which in consequence stains with difficulty; and the whole cell has once more become larger. There seems to be but one interpretation of these facts. During the time that the pancreas is secreting more rapidly, there is a diminution of the inner zone; that is to say, the inner zone furnishes material for the secretion. But while the inner zone is diminishing, the outer zone is increasing, that is to say, the outer zone is being built up again out of materials brought to it from the blood, though not to such an extent as to prevent the whole cell from becoming smaller. When digestion is ended, after the pancreas has ceased to secrete, the inner zone again enlarges, evidently at the expense of the outer zone, though the latter also continues to increase, causing the whole cell to become bigger. From thence till the next meal, there occurs a partial consumption of the inner zone, so that the outer zone becomes more conspicuous again, though the whole cell becomes smaller. Evidently out of the protoplasm of the cell, which is itself formed at the expense of the blood, the granules are formed, and these being deposited towards the lumen of the alveolus distinguish the outer homogeneous from the inner granular zone,

and the secretion is produced at the expense of the granules.

"Kühne and Sheridan Lea,* observing, under the microscope, the pancreas of the living rabbit, have been able to watch the actual process of secretion; and their results, while they extend, in the main corroborate those of Heidenhain. In the quiescent pancreas of the rabbit, Fig. 22 A, the cells are for the most part filled with granules, the transparent outer zone being reduced to small dimensions; the outlines of the individual cells are very indistinct, with the margins of the alveoli smooth; the lumen of the alveolus is obscure; and the blood supply is scanty. Upon secretion being set up, Fig. 22 B, the margins of the active alveoli become indented through a bulging of their constituent cells, the outlines of which now become distinct; the

FIG. 22.

A PORTION OF THE PANCREAS OF THE RABBIT. (KUHNE AND SHERIDAN LEA.)

A at rest, *B* in a state of activity.

a the inner granular zone, which in *A* is larger, and more closely studded with fine granules, than in *B*, in which the granules are fewer and coarser.

b the outer transparent zone, small in *A*, larger in *B*, and in the latter marked with faint striæ.

c the lumen, very obvious in *B*, but indistinct in *A*.

d an indentation at the junction of two cells, seen in *B*, but not occurring in *A*.

* Kühne, 'Ueber das Secret des Pankreas.' *Verhand. d. Naturhist. Med. Vereins zu Heidelberg*, Bd. 1. Heft 4.

granules retreat towards the inner zone, bordering on the cavity of the alveolus, and as secretion goes on, evidently diminish in number, the whole cell becoming hyaline and transparent from the border inwards; at the same time the blood vessels dilate largely, and the stream of blood through the capillaries becomes full and rapid."

In describing the general phenomena of the pancreatic secretion, some of its more prominent physical and chemical characters have been referred to; we must now examine these more closely.

Before doing so, let me, however, refer to the estimates of the quantity of pancreatic juice secreted in twenty-four hours. Assuming the amount secreted in man to be in proportion to that secreted by the dog, a man would secrete from 211 to 347 grammes (from about $7\frac{1}{2}$ to little more than 12 ounces).

In describing the general phenomena of the pancreatic secretion some of its more prominent physical and chemical characters have been referred to, though a complete description has been reserved for this section.

Physical Characters.

The juice obtained from temporary fistulae or in permanent fistulae when changes in the gland have not occurred, is, as has already been said, a more or less viscid, gluey liquid.

It contains suspended in it constantly certain morphological elements (Kühne). These are:—colourless blood corpuscles of the smaller kind, which exhibit sluggish yet perceptible amoeboid movements; corpuscles which are larger than the above-mentioned colourless corpuscles, but smaller than the so-called salivary corpuscles of mixed saliva with which, however, they agree in all other particulars. These corpuscles have in their interior granules which exhibit lively Brownian movements and possess one to four nuclei. At favourable temperatures the morphological elements are digested and dissolved.

Claude Bernard described the pancreatic juice as becoming more viscid as it cooled. Kühne has however found that when cooled (as to 0° C.) it undergoes a true coagulation, separating into a gelatinous and a diffluent part. In consequence of this property the pancreatic juice often forms compact opaque clots in silver cannulae.

The pancreatic juice is invariably alkaline; it possesses a saltish taste. The fluid of temporary fistulae has a higher specific gravity than that of even successful permanent fistulae. The former has a specific gravity of 1030, the latter between 1010 and 1011.

General Chemical Characters.

When heated on the water-bath to 75°, pancreatic juice obtained from a temporary fistula coagulates so completely as to become converted into a white opaque mass, from which there separates a slightly opalescent fluid more alkaline than the uncoagulated juice, which is precipitated by acetic acid and contains alkaline albuminate.

When pancreatic juice is dropped into water, the drops coagulate as they fall, the precipitate being soluble in NaCl and dilute acids. When dropped into very dilute acids a similar coagulation takes place, but the coagula are dissolved when shaken up with the acid.

Alcohol added to pancreatic juice produces an abundant white flocculent precipitate which even when washed with, or digested in, absolute alcohol is for the most part soluble in water at 0° C. Acetic acid does not precipitate this watery solution; after being acted upon for some time by acetic acid, a proteid precipitate is obtained on neutralization. The portion of the alcohol precipitate which is insoluble in water resembles a coagulated albumin.

The alcoholic precipitate referred to carries down with it the various ferments whose action will be described in the sequel. The pancreatic juice is precipitated by the concentrated mineral acids, by metallic salts, by tannic acid. Chlorine water added to fresh pancreatic juice occasions a white precipitate. If however this reagent be added to

pancreatic juice which has been exposed to warmth for some time, it occasions a red colour (Tiedemann and Gmelin).

Pancreatic juice undergoes putrefaction with the utmost ease. The red colour above referred to as brought about by chlorine is due to some body yet unknown which results from decomposition. In a juice which exhibits the chlorine reaction decomposition rapidly proceeds a step further, and then the reaction no longer occurs. If, however, adding impure coloured nitric acid to the now foul smelling liquid, a red colour is developed which is due to indol (? [illegible]).

Normal pancreatic juice contains three distinct ferments which will be treated of at length in the sequel. These are: 1. a proteolytic ferment which at suitable temperatures and in solutions which are neutral and faintly alkaline readily decomposes proteids with the production of peptones and amido-acids, such as leucine and tyrosine; 2. a diastatic ferment, similar to that which exists in saliva, converting starches into erythrodextrins, achroodextrins and maltose; 3. a fat-decomposing ferment which brings about the hydrolytic decomposition of the neutral fats into glycerin and fatty acids. Although these three ferments always co-exist in normal pancreatic juice, in the continuous thin secretion from permanent fistulae the second and third ferments are sometimes found unaccompanied by the first or proteolytic enzyme.

In [illegible] of freshly secreted pancreatic juice obtained from a large number of dogs, Kühne* was unable to discover a trace of tyrosine. Leucine was present, but in so small a quantity as to be only discoverable by the microscope.

The thick flowing secretion obtained from recently established fistulae (dog) contains approximately in 1000 parts:

900 parts of water.
[illegible] ,, organic solid matter.
[illegible] ,, inorganic salts.

The organic solid matter is composed mainly of proteids

* Kühne, 'Die Pankreassaft' in Hermann's *Handbuch*, [illegible] part I. p. [illegible]. The author does not know the original source whence these facts have been obtained.

and ferments. Generally, the more abundant the flow, the smaller the amount of solid matter in solution. The salts consist mainly (that is to the extent of about seven-tenths) of sodium chloride; the remaining salts are sodium carbonate, with traces of sodium phosphate, earthy phosphates and traces of iron. Thus, in the first of the analyses given in the subjoined tabular view, Schmidt found the inorganic matters per 1000 to be 8·8, and in this the NaCl amounted to 7·35.

The thin juice secreted continuously by permanent fistulae is sometimes not coagulable by heat alone, but requires the addition of an acid. It contains from 10—20 parts per 1000 of solid matters.

COMPOSITION OF PANCREATIC JUICE (C. SCHMIDT).

	I. From temporary fistulae.		II. From permanent fistulae.		
	a	*b*	*a*	*b*	*c*
Water in 1000 parts	900·8	884·4	976·8	979·9	984·6
Solids " "	99·2	115·6	23·2	20·1	15·4
containing					
Organic matters	90·4	—	16·4	12·4	9·2
Inorganic matters	8·8	—	6·8	7·5	6·1

The Pancreatic Ferments considered in Detail.

In discussing the general chemical composition of the pancreatic juice, I have referred to the fact that it possesses very remarkable properties of acting on organic bodies, and that these are supposed to be dependent upon the existence in the juice of three distinct enzymes. I further stated that when the pancreatic juice is precipitated by alcohol, the precipitate which falls carries down with it the ferments. The precipitated body has in past time been supposed indeed to constitute the ferment, and the opinion has also been expressed that this ferment is possessed of various properties. We now know, however, that the cause of the activity

of the so-called *pancreatin* is a mechanical entanglement of three ferments, which apparently are not associated with one body but are distinct bodies.

We must now in the first place carefully examine the chief facts relating to each of the ferment actions of the pancreatic juice, and study the products which take their rise in these.

Preparation of active Solutions containing the Ferment of the Pancreas.

It is exceedingly convenient to have at our disposal permanent solutions of the ferments of the pancreas.

1. All the pancreatic enzymes are extracted by glycerine from the gland, and such glycerine solutions may be conveniently preserved.

2. They are likewise soluble in a saturated aqueous solution of chloroform, and the solution keeps very well (Roberts). The presence of chloroform interferes, however with the operation of testing for sugar by Fehling's solution.

3. Roberts has found that for experimental purposes a good and lasting extract of the pancreas may be made by extracting the organ with a solution which contains "three or four per cent. of a mixture of two parts of boracic acid and one part of borax."

4. One of the best methods of preparing a very active solution of the pancreatic enzymes is the following (Roberts) in which advantage is taken of the fact that they are very soluble in water and that their aqueous solutions are preserved from decomposition by a small addition of alcohol:—

Digest fresh pancreas freed from fat and chopped up in four times its weight of dilute alcohol, containing 25 per cent. of rectified spirit (*i.e.* of alcohol of sp. gr. 0·838). The digestion is continued for four or five days with occasional agitation. The mixture is then filtered through paper. Filtration is much facilitated by the addition to the solution of 0·02 per cent. of acetic acid (containing 28 per cent. of the anhydrous acid).

5. The so-called "*pancreas-powder*" of Kühne is an admirable preparation from which solutions of the proteolytic ferments of the pancreas can be prepared at any time. It is made as follows:—Pancreas of the ox is completely extracted with alcohol and ether. There is left a white, friable, dry mass. One part by weight of this solid is digested in the incubator for four hours, with from five to ten parts by weight of a solution containing 0·1 per cent. of salicylic acid; the solution filtered from the insoluble matter is extraordinarily rich in *trypsin*.

1. *The Diastatic Ferment.*

The saliva, we have seen, is a liquid which only possesses an amylolytic action in a few animals, and the great majority of animals have a saliva which possesses no diastatic ferment.

Valentin is said to have first discovered that the pancreatic juice possessed diastatic properties; the fact was apparently independently discovered by Bouchardat and Sandras who obtained the pancreatic juice of hens and geese.

The action of pancreatic juice on raw starch is but slight, on starch mucilage it is surprisingly great. At 35° the action is so energetic that, according to Kühne, it does not admit of being estimated. The diastatic action of the diffluent, abnormal, secretion from permanent fistulae is said (Kühne) to be as powerful as that of the coherent concentrated liquid of permanent fistulae.

An infusion of the pancreas acts upon starch exactly as the pancreatic juice, and we may therefore in our experiments on the diastatic enzyme of the pancreas employ such an infusion instead of the hardly to be procured pancreatic juice.

The action of the diastatic ferment of the pancreas and pancreatic juice appears to resemble in essential particulars that of the saliva and salivary glands; *i.e.*, the products formed are the same, the conditions of activity

are similar, &c. According to Musculus and v. Mehring in both cases there are formed achroodextrins, maltose, and a little grape-sugar.

Roberts has found that the action of pancreatic diastase on starch mucilage increases in speed from zero to 30° C. From this to 45° C. the rate of action continues steady. Above 45° the action becomes slower and slower and ceases between 60° and 70°.

We have seen that within a certain range of temperature, the rapidity of the action upon starch increases. Temperature and all other conditions being exactly similar, the rapidity of the action will depend upon the quantity of enzyme present. This is well brought out in the following remarks (Roberts).

"The speed at which a given quantity of starch is transformed by diastase depends essentially on the proportion of ferment brought to act upon it. In the above experiments (experiments in which a minimal quantity of diastatic solution acted upon starch) the proportion of diastase was very minute in comparison with the amount of starch, and the action went on slowly for forty-eight hours. But if we reverse these proportions and mix a small amount of starch with a large amount of diastase the transformation is instantaneously accomplished. If a test-tube be half filled with an active extract of pancreas and a few drops of starch mucilage be quickly shaken therewith, you cannot detect the reaction of starch or dextrine in the mixture, however prompt you may be with the testing—the transformation has followed on the admixture as instantaneously as the explosion of the charge follows the fall of the trigger. Between these extremes there are all gradations."

Roberts has estimated that pancreatic diastase "is able to transform into sugar and dextrin no less than 40,000 times its own weight of starch.

Had I sufficient time at my disposal I should enter at length into the question as to whether the diastatic ferment of the pancreas exists preformed in the cells of the gland, or whether these contain an antecedent or so-called *zymogen*

of the diastatic ferment, analogous to the zymogen of the proteolytic ferment, to be afterwards briefly referred to.

I may, however, in passing, say that the researches of Liversidge carried out many years ago in Foster's laboratory, leave no doubt as to the existence of such a zymogen of the diastatic ferment.

Want of time prevents, likewise, my examining with you the evidence which leads me to assert that without doubt the several ferment actions of the pancreas depend upon distinct ferments, and are not different attributes of one body.

2. *The Fat-decomposing Ferment.*

It was in the year 1846 that Claude Bernard, being engaged in a comparative study of the process of digestion in carnivorous and herbivorous animals, was struck by the fact that when dogs were fed upon fatty matter this appeared to undergo a modification almost as soon as it passed into the small intestine, whilst when rabbits were similarly fed the change occurred somewhat further from the pylorus. Again, Bernard observed that after a fatty diet the lacteals of dogs were filled with white opalescent chyle from the pylorus downwards, whilst in rabbits the lacteals near the pylorus did not contain white chyle, while those situated lower down did. Bernard then discovered that this difference in the appearance and absorption of fatty matters coincided with the difference in the situation at which the pancreatic duct joins the small intestine in the dog and rabbit respectively. In the dog the principal duct empties itself, together with the bile duct, into the duodenum very near to the pylorus; whilst in the rabbit the principal duct joins the small intestine from 30 to 35 centimetres (12 to 14 inches) below the point of entrance of the bile duct.

When this relationship had been found to exist between the situation at which the pancreatic juice is poured into the intestine and the situation where fat begins to be modified, it was natural to inquire whether the juice was not the active agent in effecting the modification of fatty

matter, and in causing the appearance of milky chyle in the lacteals, and as the result of his investigations Claude Bernard was led to the discovery of the facts about to be commented upon.

Oil or fatty matters which are fluid at the temperature of the animal body are very readily emulsionised by the pancreatic juice.

If two parts of alkaline and viscous pancreatic juice, be shaken up in a test-tube with one part of olive oil, a perfect emulsion is almost instantly obtained, the liquid resembling milk or chyle ; the same result is obtained if we substitute for olive oil fats, such as butter or mutton suet, which melt at a temperature below 40° C. Temperature appears to have considerable influence in the process. Thus, when one gramme of lard is agitated with two grammes of fresh, normal, pancreatic juice, the process of emulsionising commences even in the cold, but when the temperature is raised to 35° or 38°, a white creamy emulsion is obtained instantly. Emulsions obtained in this way are remarkably persistent, and, according to Kühne, the fat in them exists in even a finer state of division than in milk.

The so-called Pancreatic Emulsion of Messrs. Savory and Moore, which for many years has been used in medicine, is a preparation in which this power of the pancreas of bringing about the emulsionising of fats has been taken advantage of, so as to obtain fats in an extremely fine state of division, in which condition they appear to be most readily absorbed from the alimentary canal.

Claude Bernard was led to believe that the property of emulsionising fats which the pancreatic juice possesses in so extraordinary a degree, depended upon a ferment, which at the same time occasioned the remarkable change to be immediately referred to, and which he termed the '*Emulsive Ferment*.' In this view Bernard was probably wrong. It is probably only in an indirect way that a ferment leads to the emulsionising of the fats.

Brücke has shown that when an oil or a fat which contains a mere trace of free acid, is shaken with a weak solution of

carbonate of soda, an emulsion is readily obtained, whilst if the oil be perfectly neutral no such emulsion is obtained. It will be shown that at the temperature of the body the pancreatic juice does lead to the acidification of fats ; as the juice does contain carbonate of soda, the conditions arise readily which are required for the production of an emulsion. It is remarked by Kühne, and with justice, that probably the proteid matters in the pancreatic juice play an important part in the emulsionising action.

Bernard discovered that when emulsions are made by mixing fresh, alkaline pancreatic juice with a neutral fat, such as olive oil or lard, and the emulsions are maintained at the temperature of the animal body, an acid reaction is very soon developed. The observation has been confirmed again and again, by Berthelot amongst others.

Claude Bernard had found that when butter is kept at the temperature of the body with pancreatic juice, the odour of butyric acid is soon perceived.

Berthelot tried the experiment with synthetically prepared monobutyrin, and found that by the action of pancreatic juice upon it there was obtained besides undecomposed monobutyrin, a mixture of free glycerin, butyric acid and a soap.

The property which the pancreatic juice possesses of decomposing the neutral fats is shared by the pancreatic tissue itself ; it is indeed laid down by Claude Bernard as the characteristic of this tissue that it possesses the property of *instantaneously* decomposing butyrin.

This property is, however, only possessed by the perfectly fresh tissue of the pancreas, and by extracts made with peculiar care. It is, however, unquestionably possible to obtain clear glycerin-extracts of pancreas endowed with powerful fat-decomposing properties.

Grützner has found that the richness of the pancreas in the fat-ferment varies, and in the same sense as its richness in diastatic and proteolytic enzymes. Thus the pancreas of a dog is poorest in the fat-ferment about six hours after a rich meal. Thereafter the amount increases up to the

fortieth hour, so that the pancreas of fasting animals is richest in the fat ferment.

Grützner believes that the central zones of the pancreatic cells not only form the proteolytic, but likewise the fat-decomposing and diastatic ferments.

The action exerted by the fat-decomposing ferment is one in which the fat combines with the elements of water; an example of what is often termed a hydrolytic decomposition. The following is the reaction which occurs under the influence of the ferment when stearin is decomposed.

$$\underbrace{C_{57}H_{110}O_6}_{\text{Tristearin.}} + 3\ \underbrace{H_2O}_{\text{Water.}} = \underbrace{C_3H_8O_3}_{\text{Glycerin.}} + 3\ \underbrace{C_{18}H_{36}O_2}_{\text{Stearic Acid.}}$$

3. *The Proteolytic Enzyme of the Pancreas—Trypsin.*

Corvisart first discovered that pancreatic juice possesses in a very high degree the property of digesting proteids, and that, indeed, weight for weight, it possesses a much more intense proteolytic activity than the gastric juice.

Strongly opposed by Claude Bernard, the experimental results of Corvisart did not attract the attention which they deserved, and it was not until a now famous research of Professor Kühne, that serious attention was again paid to the proteolytic action of the pancreas.

Kühne pointed out that if the finely divided pancreas of a dog in active digestion be made to act upon well boiled blood fibrin, suspended in water, preferably with the addition of a small quantity of sodium carbonate or hydrate, the fibrin is dissolved in large quantities.

The solution is found to contain besides certain intermediate products of digestion, large quantities of peptones, and considerable quantities of leucine and tyrosine, two bases to which reference will again be made. Usually, unless special precautions are taken, the products of digestion assume an intensely foul odour, due chiefly to the presence of indol and skatol.

The first researches of Kühne have been in the fullest degree confirmed and much extended.

From these it results that the pancreatic juice contains a ferment to which he has given the name of *Trypsin*, which possesses, like Pepsin, strong proteolytic powers. Unlike pepsin, trypsin is absolutely inactive in a strongly acid solution, and indeed at a favourable temperature, trypsin is digested and destroyed by pepsin and hydrochloric acid, and even by the latter alone. Trypsin acts most favourably when present in an alkaline solution, as for instance in a solution containing from one to two per cent. of sodium carbonate, or sodium hydrate. It is to be noted, however, that whilst pepsin is only active in a solution containing *free acid*, *trypsin* can digest in a *feebly acid*, *neutral* or *alkaline* solution, the latter being however much the most favourable.

Long heating, even at moderate temperatures, however, soon destroys the activity of an acid solution of trypsin, just as long digestion of an alkaline solution of pepsin destroys the ferment.

Whilst the production of peptones and amido-acids is rapidly brought about under favourable conditions of temperature and alkalinity, by trypsin alone, the putrid decomposition which has been already referred to as frequently supervening in the course of pancreatic digestion, has nothing whatever to do with trypsin, but is connected with the development of bacteria.

I shall not trouble you with a description of the highly complex processes whereby Kühne has attempted to isolate trypsin—processes which have led to the separation of a body which is a proteid, and which possesses in an intense degree the power of pancreas extracts, to dissolve proteid bodies. It may be, that the ferment in the purest form in which it has been obtained is in reality a mixture of an albuminous substance and a non-proteid ferment. This view, which is supported by the analogy of pepsin, is, however, by no means more probable than that which considers trypsin as containing a proteid body endowed with marvellous ferment actions, for I would point out that the pancreatic juice differs from any other secretion of the body in the fact that it is, normally, intensely coagulable.

I have already referred to the discovery which Heidenhain made that the pancreas does not contain when at rest ready-formed trypsin, but an antecedent or precursor of the ferment, to which he gave the distinctive name of Zymoyen, *i.e.* a body which under various circumstances, when contained in the gland or in extracts of it, may yield the ferment. The accuracy of the fact has received full confirmation, and in the case of other ferments (*pepsin* and the *rennet ferment*), antecedents have been found, which we must call their special zymogens, so that we are compelled to define the special ferment antecedent which we are now considering " *Trypsin-zymogen.*"

Recalling what we have already said of the characteristics of the secreting cells of the pancreas, you will remember that whilst they differ but little microscopically from those of such a salivary gland as the parotid, they exhibit very marked differences, corresponding to their different states of functional activity. During a period of glandular repose the cells appear large, and contain innumerable granules, which are congregated at that side of the cell which lies towards the centre of the acini. The outer or peripheral portion of the cells—the smaller part of the resting cell—is clear. After a period of glandular activity the granular half of each cell is found to have diminished greatly ; the whole cell is clear and distinctly smaller than before, and its behaviour towards colouring matters is very different. The pancreas, when perfectly fresh and just removed from the yet warm body of an animal which is killed, does not contain, ready formed, all the ferments which will in the sequel be referred to as characterizing the pancreatic juice. If we treat the gland, for instance, with glycerin, which possesses the power of extracting and dissolving all the ferments, we fail to obtain a solution which possesses the power of digesting proteids ; but, instead, we find in the solution a substance from which, by the addition of a little acetic acid, the proteolytic ferment may be formed. The cells of the pancreas thus elaborate a substance which is

the antecedent of the proteolytic ferment, and which yields it when it passes into the pancreatic ducts.

The secretion of pancreatic fluid is slight except during digestion. After the taking of a full meal the secretion is suddenly exalted, reaching its maximum two or three hours afterwards. The secretion then diminishes until a period which extends from the fifth to the seventh hours, when a rise occurs, which lasts to between the ninth and eleventh hours after food. The secretion then gradually sinks, until it absolutely ceases.

Stimulation of the gastric mucous membrane starts the secretion of pancreatic juice ; it is arrested during nausea and vomiting, as also when the central end of the divided pneumogastric is stimulated.

In my last lecture I shall examine with you more carefully than I have yet done the products of the pancreatic digestion of proteids, and touching briefly upon the other changes which have their seat in the alimentary canal, conclude this brief sketch of the Function of Digestion by a reference to the channels by which the products of digestion are conveyed to the blood, and by an outline of certain of the chemical processes of nutrition.

LECTURE VI.

THE PRODUCTS OF THE PANCREATIC DIGESTION OF PROTEIDS — INTESTINAL JUICE — ACTION OF FORMED FERMENTS IN SMALL AND LARGE INTESTINES—ABSORPTION OF THE PRODUCTS OF DIGESTION.

IN my last lecture, besides giving you a general sketch of the action of the pancreatic juice on proteids, I pointed out with some care the main differences between trypsin and pepsin. I now wish to treat, though in a very elementary manner, of the nature of the changes brought about in proteids by these two ferments.

The various ferments of the alimentary canal all resemble in this,—that the changes they bring about are decompositions of complex into simpler bodies, the complex bodies combining with the elements of water before decomposition—decompositions which, since Hermann introduced the expression, have been termed "Hydrolytic." Thus we saw that the results of the diastatic action of saliva upon starch might be represented by the equation—

$$\underbrace{{}_{10}(C_{12}H_{20}O_{10})}_{\text{Starch.}}+8(\underbrace{H_2O}_{\text{Water.}})=\underbrace{C_{12}H_{20}O_{10})_8}_{\text{Achroo-dextrin.}}+8(\underbrace{C_{12}H_{20}O_{11}}_{\text{Maltose.}})$$

And that the action of the fat decomposing ferment of the pancreas upon stearin might be represented by the equation—

$$\underbrace{C_{57}H_{110}O_6}_{\text{Tristearin}}+3\underbrace{H_2O}_{\text{Water}}=\underbrace{C_3H_8O_3}_{\text{Glycerin.}}+3\underbrace{(C_{18}H_{36}O_2)}_{\text{Stearic Acid.}}$$

In these cases we have complex molecules combining with the elements of water and breaking up into much more simple molecules.

The decompositions brought about by these ferments are very similar; in the second case referred to, indeed, abso-

lutely identical with those which are occasioned by the action of superheated steam, or by the long continued action of mineral acids of greater or less strength.

In the case of starch, the action of dilute mineral acids is to break up the complex molecule into simpler isomeric molecules, various dextrins, the ultimate product being a sugar: not, it is true, identical with that chiefly produced by diastatic ferments, viz. maltose, but readily obtained from the latter, viz. grape sugar.

The products of the action of the proteolytic ferments of the alimentary canal, similarly, presents great resemblance to the substances obtained from proteids by the action of superheated steam, or by long boiling with more or less diluted mineral acids, though, as might be expected, minor differences result from the difference in the conditions.

Essentially, however, it may be stated that the processes are similar in the various cases, and that, under the influence of pepsin and trypsin, the proteid molecule, which is of very high complexity, is resolved into bodies of simpler molecular weight and of less complexity.

The subject which is engaging our attention is one of great difficulty and of remarkable complexity, and I can only pretend to give you, somewhat dogmatically, an outline of the views which have been advanced on this matter by the eminent scientific man who has chiefly investigated it.

Kühne several years ago advanced the idea that when the proteid molecule is digested by means of pepsin and dilute hydrochloric acid, the complex molecule is decomposed (probably hydrolytically) into simpler bodies, belonging to two groups—a *hemi*-group and an *anti*-group, the ultimate products being *peptones;* those derived from the hemi-group being hemi-peptones, and those derived from the anti-group being anti-peptones.

Though possessed of essentially the same reactions, the great and characteristic difference between the two kinds of peptones being, according to Kühne, that anti-peptones are remarkably stable, whilst hemi-peptones, under favourable conditions, as for instance under the influence of trypsin in

presence of an alkali, are decomposed, with the production of other bodies, amongst which are most conspicuous—

Leucine ($C_6H_{13}NO_2$) and Tyrosine ($C_9H_{11}NO_3$)

The following represents the scheme of the proteolytic digestion of proteids by Pepsin, according to Kühne :—

Albumin + Pepsin + Dil. HCl.

Anti-Albumose. Hemi-Albumose.

Anti-peptone. Anti-peptone. Hemi-peptone. Hemi-peptone.

Many looked upon the very briefly and somewhat dogmatically expressed views of Kühne as purely hypothetical, though their probability was enhanced by the studies of Schützenberger who, following other methods of decomposing proteids, had discovered similar facts and arrived at similar conceptions. The further researches of Kühne carried out in conjunction with Chittenden have, however, singularly confirmed his views, and have demonstrated the actual existence of several definite products of digestion whose existence had been previously little more than surmised.

Hemi-albumose is perhaps the best studied of the intermediate products of the digestion of proteids. It is a body which was described by Meissner as A—Peptone ; it is, like the true peptones, highly soluble in water and gives the characteristic ' peptone ' rose reaction, to which I previously referred, when treated with cupric sulphate and sodium hydrate. It is, however, distinguished from peptones by the following reactions.

1st. It is precipitated from its solutions by acetic acid and solution of potassium ferrocyanide ; unlike the precipitate produced under these circumstances by proteids in general, that yielded by hemi-albumose disappears on heating and reappears on cooling.

2nd. It is precipitated from its solutions when these are heated, and reappears on cooling.

3rd. It is precipitated by dilute nitric acid, the precipitate dissolving when the solution is heated and reappearing when it is cooled.

4th. It is precipitated when its solutions are acidified with acetic acid and strong solution of sodium sulphate and boiled.

5th. It is precipitated by metaphosphoric acid.

Hemi-Albumose can be obtained by interrupting peptic-digestion and neutralizing the solution. The precipitate contains anti- and hemi-albumose. The latter is separated in virtue of a property which it possesses of being soluble in five per cent. solutions of sodium chloride.

Apart from the *conditions* favourable to the digestion of proteids by pepsin and trypsin, the essential difference is that pepsin can only split up proteids to a certain extent—reducing them to the state of peptones—whilst trypsin can act upon one group of these and further split them up.

The scheme of trypsin digestion is as follows :—

Proteid + Trypsin.

- Anti-Albumose.
  - Anti-peptone.
  - Anti-peptone.
- Hemi-Albumose.
  - Hemi-peptone.
    - Leucine. &c.
    - Tyrosine. &c.
  - Hemi-peptone.
    - Leucine. &c.
    - Tyrosine. &c.

I would direct your attention very particularly to the fact that whilst Leucine and Tyrosine are the most characteristic and readily identified of the further decomposition products of the hemi-peptones, there are unquestionably others.

With reference to Leucine and Tyrosine I would add the following remarks. The former body, which has the empirical formula $C_6H_{13}NO_2$ may be represented as

$$\begin{array}{l} C_5H_{10}\text{—}NH_2 \\ | \\ COOH \end{array}$$

and is amido-caproic acid.

Tyrosine, on the other hand, is a more complex body, which we may regard as Parahydroxylphenyl-alpha-amido-propionic acid.

$$C_6H_4\begin{cases} OH \\ C_2H_3\begin{cases} NH_2 \\ COOH \end{cases} \end{cases}$$

Before leaving the products of artificial pancreatic digestions, I must mention that on the addition of a weak solution of bromine in water to a liquid in which pancreatic digestion is already proceeding, a violet colour is developed.

Having studied the products which are obtained when proteids are artificially digested with the proteolytic ferment of the pancreas, we naturally ask ourselves the question: how far do the processes which go on in the alimentary canal resemble those which occur *in vitro?* To this question

I shall give an answer in a general survey of the digestive processes of the small intestines.

The Intestinal Juice.

By the name of intestinal juice, or *Succus Entericus*, we designate the liquid which is secreted by the glands of Lieberkühn, which, as I have told you, are found in the mucous membrane throughout the whole small intestines. Very little is known as to the properties of this fluid. According to the most known accounts, it is an alkaline fluid of specific gravity of 1011, and containing about 2·5 per cent. of solid constituents. It appears to possess very little, if any, proteolytic power, but has a slight diastatic action, and is said to contain an inverting ferment, *i.e.* a hydrolytic ferment which decomposes cane sugar into grape sugar and an isomeric sugar called levulose, thus—

$$\underbrace{C_{12}H_{22}O_{11}}_{\text{Cane Sugar.}} + \underbrace{H_2O}_{\text{Water.}} = \underbrace{C_6H_{12}O_6}_{\text{Levulose.}} + \underbrace{C_6H_{12}O_6}_{\text{Dextrose or Grape Sugar.}}$$

A Survey of the whole Digestive Processes in the Intestines.

We are now in a position to combine the information which we have obtained, and to give a brief summary of the processes which go on in the small and large intestines.

I told you that after sojourning in the stomach for a considerable time the chyme containing both soluble constituents which had escaped absorption in the stomach and yet unacted upon insoluble constituents, passed the pyloric valve and entered the duodenum. Coming in contact with the bile and pancreatic juice, pepsin digestion comes to an end and trypsin digestion commences ; the proteids which have escaped the action of gastric juice succumb to the action of trypsin. The digestion of starches which had been arrested by the acidity of the stomach recommences under the influence of the diastatic ferment of the pancreas, whilst the fats, under the influence both of the bile and the pancreatic juice, are rapidly emulsified.

To what extent, it will be asked, does the digestion of proteids proceed under the influence of the pancreatic juice? Are all the insoluble proteids dissolved, and, if so, do the hemi-peptones as in the beakers in our laboratory, fall to pieces in the intestines, and yield us leucine, tyrosine, asparagine, glycocoll, and other bodies?

To these questions I would answer, that unless under very exceptional circumstances, the proteids which have passed the pyloric valve are completely dissolved, and rendered fit for absorption, so that the fæces of animals fed upon a very large excess of meat do not contain proteids, unless the excess in diet has led to morbid conditions. Whether the hemi-peptones undergo to any considerable extent decomposition, into leucine and tyrosine, is however very problematical. In all probability the peptones are absorbed almost as soon as they are produced, and find their way into the blood, and I hold it to be exceedingly unlikely that in health any but traces of leucine and tyrosine are absorbed.

The various processes which I have referred to are greatly aided by the movements of the intestinal canal, and are associated with the processes of absorption to be afterwards briefly glanced at.

If we except the inverting action exerted by the intestinal juice, it is probable that this fluid plays little but a mechanical part in intestinal digestion.

As the contents of the intestine are followed from above downwards, they are observed to undergo a great diminution in amount, owing to the absorption of water holding the diffusible products of digestion in solution. As the contents pass from the small into the large intestine the reaction which had been alkaline becomes acid, and products of putrefactive decomposition make their appearance.

In this part of the alimentary canal the action of unformed ferments ceases, and the changes which occur are due to *organized ferments*. In some animals, as in the herbivora, the influence of these is probably of the greatest importance, breaking up such constituents as cellulose,

which, as my own experiments long ago showed me, is unacted upon by any of the unorganized ferments of the alimentary canal.

The Intestinal Movements. The Fæces.

When the gastric contents, to which the term chyme is often applied, pass through the pylorus into the duodenum, they begin to move onward by the peristaltic action of the small intestines. The powerful annular fibres contract one after another, driving the food onward, as water may be squeezed along an india-rubber tube by the compression of the hand. The longitudinal fibres contract in such a manner that the intestine is drawn over the advancing mass. The movements always occur (in health at least) in a direction from the stomach to the ileo-cæcal valve; here they stop and never pass as a continuous wave to the large intestine.

Peristalsis may be exhibited by an excised intestine independently of any extrinsic nervous apparatus. Stimulation of the vagus nerve, as a rule, excites the intestinal movements, while excitation of the splanchnic nerves tends to still them. When the blood stagnates in the intestinal vessels active peristalsis ensues. As the splanchnic nerves are also the vaso-motor nerves of the intestines, their excitation produces constriction of the blood-vessels and comparative bloodlessness.

After passing through the ileo-cæcal valve the intestinal contents, which have been very greatly diminished in amount owing to the process of absorption which has gone on quickly, assume the characteristic appearance of fæces. The undigested and insoluble parts of the food, mixed with mucus, with epithelial débris, and with some substances derived from the secretions of the alimentary canal, notably with some biliary products, must be cast out; this is effected by the act of defæcation. The anus is normally kept firmly closed by the contraction of two sphincter muscles,—the external, which is one of the skeletal muscles, and the

internal, which is formed by a special development of the lowest rings of the circular layer of muscles of the intestine. In the act of defæcation these sphincters are relaxed, while the contraction of the rectum forces its contents downwards. The levatores ani are brought into play by the will and exert an action similar to that previously referred to as performed by the longitudinal fibres of the intestine. Of special influence in aiding the expulsion of the contents of the bowel is the contraction of the abdominal muscles which follows a preliminary fixation of the diaphragm by a deep inspiration.

The act of defæcation is essentially a reflex act. The centre, which presides over the sphincters of the anus, lies in the lumbar portion of the spinal cord. This centre is under the control of the brain, under the influence of which its activity is either increased or inhibited.

Absorption of the Products of Digestion.

Absorption of material from the alimentary canal takes place, in part, directly by its passage into the blood-capillaries, and, in part, indirectly, by its passage into the lymphatics, which are exceedingly abundant in the mucous membrane of the stomach and intestines.

Water, soluble salts, dextrins (?), sugars, peptones, perhaps some of the intermediary products of proteid digestion, such as hemi-albumose as well as emulsioned fats, are the materials present in the alimentary canal which are taken up by the blood-vessels and lymphatics.

That absorption of water occurs in the stomach with remarkable rapidity is proved by the instant alleviation of thirst when water is drunk—an alleviation which of necessity implies the passage of water into the blood; the quick absorption of some highly diffusible bodies is similarly proved by the very rapid excretion of some salts, as, for instance, of potassium iodide, by the salivary glands and by the kidneys, when these salts have been swallowed. In the stomach, doubtless, water and the more highly diffusible

constituents, are rapidly absorbed, and in all probability to a greater extent by the capillaries than by the lymphatics. We cannot suppose, however, that the exceedingly abundant lymphatics of the mucous membrane have no important absorbent functions, though we cannot positively assert what precise share of the work of absorption falls to them.

It is in the small intestine, doubtless, that absorption of the dissolved organic solids of our food chiefly occurs. The large surface of the mucous membrane of this part of the alimentary canal, with its innumerable villi, offers an absorbing surface of large extent pervaded by meshworks of capillaries, and by the commencement of the lymphatics "the *lacteals*." In considering the extent of this surface, let me here particularly draw your attention to the peculiar arrangement of *valvulae conniventes* which I referred to in my second lecture. These so-called valves are crescentic folds of the mucous membrane, which is doubtless arranged in this manner to afford in a given area a larger amount of absorbing surface than would otherwise be possible.

FIG. 23.

SECTION OF INTESTINE WITH A PORTION OF THE WALL REMOVED TO EXHIBIT THE VALVULAE CONNIVENTES (QUAIN'S ANATOMY).

The peristaltic movements of the intestines as a whole, the slighter movements of the mucous membrane and its folds, through the action of the Tunica Muscularis Mucosae, lead to a mixing and progressive movement of the intestinal contents most favourable to absorption.

Before examining particularly the part played by those most important structures *the villi*, in the absorption of nutritive matters from the small intestine, let me refer to

what I said concerning them and the lymphatics of the alimentary canal, in my second lecture, drawing your special attention to diagrams which will illustrate the points of greatest physiological import.

"A further enlargement is effected in the small intestine in an exceedingly interesting fashion; the surface of the mucosa is thickly studded with innumerable, fine, short projections resembling the pile of velvet. These are invested by surface epithelium, and amongst them, at their feet, open the before-mentioned *crypts of Lieberkühn.* They are the so-called *villi.* Each contains a lymphatic vessel, blood-vessels, and involuntary muscular fibres, all supported by adenoid connective tissue like that of the mucosa below;

FIG. 24.

THE LACTEALS AND LYMPHATICS OF THE SMALL INTESTINE. (QUAIN'S ANATOMY.)

the lymphatic is in the axis of the villus, the muscles form the next layer, and the blood-vessels lie immediately beneath the epithelium. When the muscular layer of the

villus contracts it must of necessity compress the lymph vessel, whilst causing no impediment to the flow of blood.

"We have described the mucous membrane of the stomach and intestines as containing a framework of adenoid reticular tissue like the tissue of lymphatic follicles. It is, indeed, identical with this,—a network of branched cells with oval nuclei, and the meshes of which are crowded with lymph corpuscles with round nuclei. At certain points in the intestines the adenoid tissue of the mucosa presents local nodular enlargements; the mucosa at these points becomes so much thicker that it swells up at the free surface beneath the epithelium into rounded eminences about as large as millet-seeds or the heads of small pins; and at the under surface of the mucosa it dips into the submucous tissue in a similar manner. At the base of this nodule of adenoid tissue in the submucosa there is usually a network of wide, thin-walled, lymphatic vessels. Many of these rounded masses are scattered irregularly over small and large intestines as the *solitary follicles* or *glands* (Fig. 25, *a*), but at the lower end of the ileum they form little colonies, often covering an area an inch or more in length, and they are situated

a FIG. 25. *b*

a SOLITARY GLAND WITH VILLI. *b* PEYER'S PATCHES.
(GRAY'S ANATOMY.)

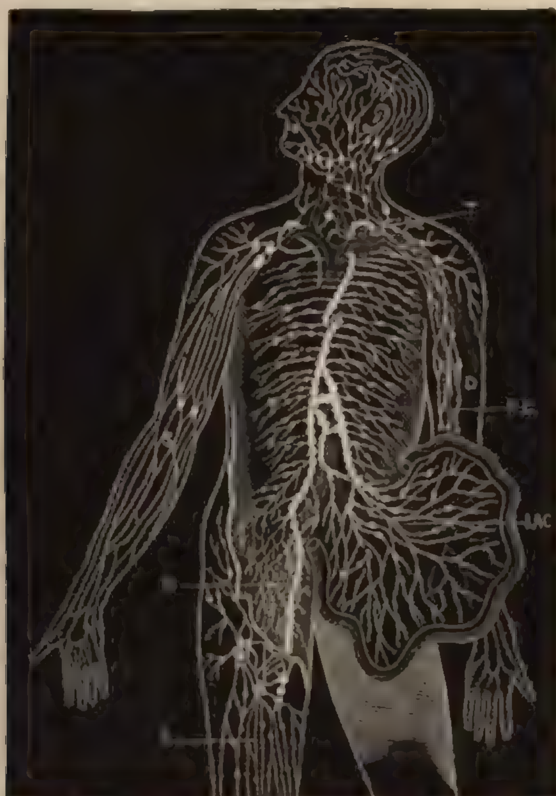
at that part of the intestine which is remote from the

attachment of the mesentery. They then constitute the so-called *Peyer's patches* (Fig. 25, *b*).

Nodular adenoid masses are, however, not limited to the adenoid mucosa of the intestines.

The whole of the intestines, and the stomach as well, are sustained in the abdominal cavity by sheets of delicate membrane, formed by folds of peritoneum, and called, in the case of the intestinal portion of the tube, the *mesentery*.

FIG. 26.



THE LYMPHATICS OF THE BODY.

Lac. The lacteals opening into the *receptaculum chyli* (R.C.), whence passes the thoracic duct, which opens at T, at the junction of the left sub-clavian and jugular veins. (*Yeo's Physiology.*)

Between the layers of the mesentery run the vessels and

nerves for the supply of the bowel. In addition to blood-vessels there are numerous thin-walled lymphatic vessels called *lacteals*, which are fed by the rich network of lymphatic vessels of the mucosa and submucosa, and which run in the mesentery to the back of the abdominal cavity. Here they are collected into a large lymphatic reservoir, the *receptaculum chyli*, from which a duct, the *thoracic duct*, proceeds along the side of the vertebral column to open into the venous system at the junction of the subclavian and jugular veins on the left side of the neck. The lacteal and lymphatic vessels, whose course has been briefly sketched, are interrupted at many points by the presence of lymphatic glands. These may be simply regarded as labyrinthine systems of vessels into which the simple *afferent* lymphatic or lacteal vessels open, and each of which is surrounded and penetrated by adenoid connective tissue, like that of the intestinal mucosa. The lacteal vessels after food are filled with a milky fluid, the *chyle*. They were discovered by Aselli in the year 1662."

The part played by blood vessels and lymphatics in the absorption of the nutritive matters from the small intestine is not perfectly understood, though in all probability the following statement is true. The absorption of dissolved and diffusible matters, such as salts, sugars and peptones is carried on by the capillaries of the villi; unquestionably during digestion both sugars and peptones are found in the blood coming from the small intestine. The emulsionized fats make their way, however, almost entering into the lacteals of the villi.

The lymphatics as a whole convey back to the blood the liquid which has transuded from the capillaries, and which has given up certain of its constituents to the anatomical elements of the tissues which it has bathed, whilst it has removed from them products of oxidation and waste, particularly CO_2. This liquid is called *Lymph*. The lymphatics of the alimentary canal, however, during digestion carry to the blood, lymph loaded with emulsioned fats, so that it is white as milk, and it is then called *Chyle;* this fluid is, as has been said, discharged into large veins near the heart

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The blood, we therefore see, is directly nourished with fatty matters absorbed from the intestine through the Chyle.

The Relations of the Liver to absorbed Matters.

If we exclude the fatty matters which, as I have told you, make their way chiefly into the lacteals and thence to the thoracic duct which conveys them into the blood, the substances absorbed into the intestine are mainly carried by the capillaries of the mucous membrane into the small venous radicles which pass into larger veins.

All the veins carrying blood back from the organs of digestion, and certain of their accessory organs, unite to form one larger vein, the Portal Vein or "Vena Portae." In the diagram now before us (Fig. 27) are shewn the chief branches which unite to form the Portal Vein. These veins bring the blood back from the stomach, spleen, pancreas, and gall-bladder, and from the small and large intestine. As will be seen by a reference to the diagram the greater number of the tributary branches of the portal vein unite first of all into two branches, termed the *splenic vein* and the *superior mesenteric vein*, and these joining behind the pancreas constitute the Vena Portæ, which after receiving veins from the stomach (*coronary veins*) enters the transverse fissure of the liver.

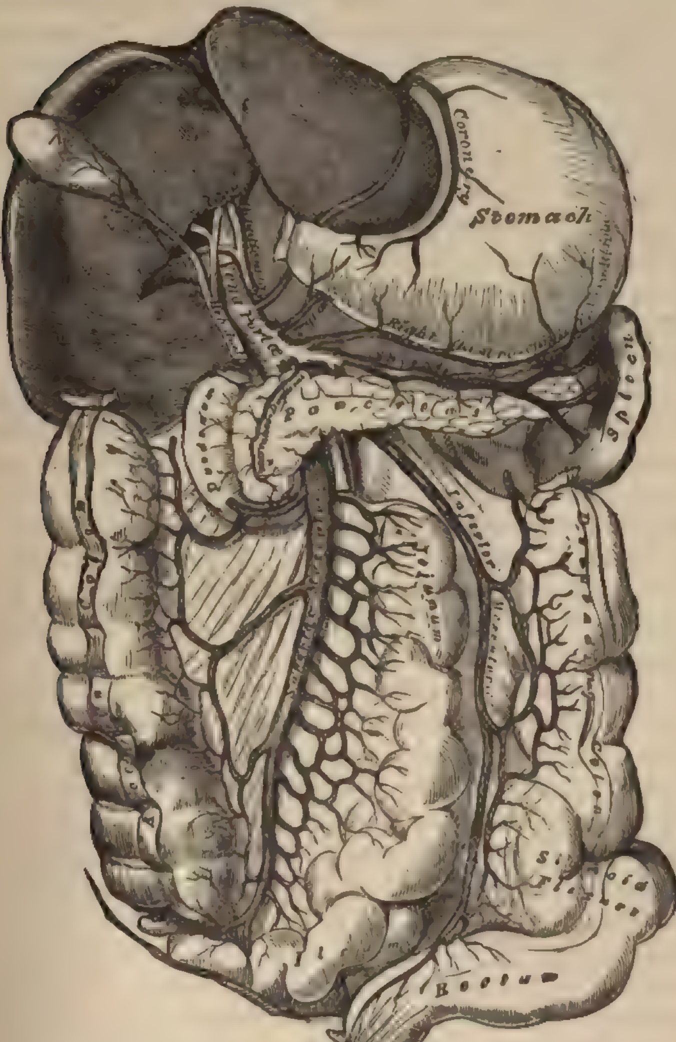
Venous blood is blood which has circulated through a capillary system, and in general is distinguished from the blood of arteries by its darker colour, by its smaller proportion of "respiratory" oxygen, and by its greater proportion of carbon dioxide. The blood of the portal vein differs from venous blood in general, however, in that after digestion, it contains the substances absorbed from the alimentary canal and the greater part of all the matters which are required to make up for the losses of the body—water, the products of "proteolytic" digestion, dextrins, and sugars.

Can we distinguish all the various constituents in portal blood, and in such amount as we might expect?

Unquestionably after digestion of a starchy or saccharine meal the portal venous blood does contain a larger quantity of sugar than the blood of any other vessel in the body.

Unquestionably, too, traces of peptones may be discovered by appropriate methods in such blood, though many have (through faulty methods) failed to discover them.

FIG. 27.



THE PORTAL VEIN AND ITS TRIBUTARIES. (GRAY'S ANATOMY.)

It is mainly owing to the observation of the second class of observers, that the view has come generally to be held, though it cannot be said to rest upon good evidence, that in the very act of passing from the intestines into the blood vessels, peptones are in part or wholly immediately reconverted into normal albuminous substances. This reconversion necessitates—if the views which I have explained to you on proteolysis be correct—an actual synthetic reconstruction of the molecule of albumin. Whether as dextrins or sugars, as peptones or reconstructed albumins, the main part of the proteids from the alimentary canal are, however, together with water, carried to the liver by the blood which flows along the portal vein.

In general, the veins of the body are formed by the union of capillary vessels, and joining with other veins, find their way into one or other of the great veins (the so-called *venae cavae superior et inferior*), which open into the right auricle. But the portal vein is the most striking exception to this common plan. Having entered the liver, it breaks up into innumerable small veins, which in their turn, form fine capillary meshworks. Amongst which are packed the myriads of secretory liver-cells. From these capillary systems there arise small veins which, uniting together, ultimately pass as so-called hepatic veins, and empty into the *vena cava inferior.*

What can the object be of having this immense gland the liver, in the path of the blood coming back from the digestive organs, charged with the products of digestion?

Before answering, in however brief and elementary a manner, this interesting question, let me point out that the blood which passes from the portal vein into its capillaries is circulating under a much lower pressure than the blood of capillary areas in general, and that in spite of certain facilities afforded by the nearness of the hepatic veins to the thorax, which exerts an aspirating influence upon the blood of the veins which enter it, the circulation through the liver substance must be an unusually slow one, as if to induce

a thorough action of the liver cells upon the matters transmitted from the portal blood.

Let me again point out to you that the blood which leaves the liver is much hotter than the blood which enters it; that the liver is the seat of the production of much heat, which of necessity is produced by the chemical actions going on within it, presumedly by the falling to pieces of more complex into more simple chemical compounds.

Having mentioned these facts, I may then inquire into some of the functions unquestionably exercised by the liver.

In the first place, when an animal is fed upon starches or sugars, we find that the liver stores up large quantities of "glycogen," a carbohydrate which has the same percentage composition, i.e., which is isomeric with the starches and dextrins, having the formula $(C_{12}\ H_{20}\ O_{10})_n$; this is a carbohydrate, doubtless of smaller molecular weight than the sugar from which the liver manufactures it. It is most readily converted into sugar.

When, therefore, the body receives large quantities of carbohydrates and sugars, instead of these passing as sugar directly from the alimentary canal into the blood, they are arrested by the liver, which stores them up as glycogen.

But what are the subsequent transformations of glycogen? you will ask. A question which I cannot satisfactorily answer.

When this matter was first enquired into by the great Claude Bernard, the simplest and most obvious explanation was given, based upon experimental evidence which has since, in the opinion of the most eminent scientific men, been found to be unreliable. The explanation was, that glycogen was as it were gradually paid out by the liver which had stored it, as grape sugar, which passing into the blood was there burned. This passage of sugar from the liver into the blood, which certainly occurs in the disease which we know as diabetes mellitus, does not occur in health. What then becomes of glycogen? It doubtless passes away from the liver in forms which as yet have escaped our detection, and in all

THE

PRINCIPLES OF COOKING.

BY

SEPT. BERDMORE,

AUTHOR OF "THE KITCHEN AND THE CELLAR" IN 'A SCRATCH TEAM OF ESSAYS.'

CONTENTS.

THE

PRINCIPLES OF COOKING.

INTRODUCTION.

"Wo was his *coke*, but if his sauce were
Poinant and sharpe and redy all his gere."
CHAUCER—*The Prologue*, v. 353.

"The company of cooks at Athens was in high esteem, and its duties were connected with the National religion."—ATHEN. xiv. 23.

I WILL take from the Introductory Lecture by the President of the Cleikum Club, which may be found in Mistress Margaret Dod's 'Manual,' the light and humorous remarks by an adept at this subject :—

"Gentlemen, man is a cooking animal; and in whatever situation he is found, it may be assumed as an axiom, that his progress in civilisation has kept exact pace with the degree of refinement he may have attained in the science of gastronomy. From the hairy man of the woods, gentlemen, digging his roots with his claws, to the refined banquet of the Greek, or the sumptuous entertainment of the Roman,* from the ferocious hunter, gnawing the half-broiled, bloody collop, torn from the still-reeking carcass, to the modern *gourmand*, apportioning his ingredients and blend-

* Cœlius Apicius, who lived in the time of Tiberius, is the one who has left us the history of Roman cookery. Of this book, the best edition was printed in London in the year 1705, with notes by Dr. Martin Lester, Physician to Queen Anne.

ing his essences, the chain is complete! First, we have the brutalized digger of roots; then the shy entrapper of the finny tribes; and next, the fierce, foul feeder, devouring his ensnared prey, fat, blood, and muscle! The next age of cookery may be called the pastoral, as the last was that of the hunter. Here we have simple mild broths, seasoned, perhaps, with herbs of the field, and the kid seethed with milk. From the Gothic and Celtic tribes emerged the Chivalrous, or rather Feudal age of cookery—the wild boar roasted whole, the lordly swan, &c. Cookery had made considerable progress in England before the Reformation. We find the writers of those ages making large account of an art from which common sense, in all countries, borrows its most striking illustrations and analogies. The ambitious man 'seeks to rule the roast;' the meddling person 'likes to have his finger in the pie;' 'meat and mass hinder no business;' the rash man 'gets into a stew,' and 'cooks himself a pretty mess;' 'a half loaf is better than no bread;' 'there goes reason to the roasting of an egg;' 'fools make feasts, and wise men eat them;' 'the churl invites a guest, and sticks him with the spit;' 'the belly is every man's master;' 'he who will not fight for his meat, what will he fight for?' 'a hungry man is an angry man;' 'it's ill-talking between a full man and a fasting;' 'it is the main business of every man's life to make the pot boil;' or, as the Scots more emphatically have it, 'to make the pot play brown,' which a maigre pot will never do." [Here we have the origin of the term "pot-boiler" applied to the pictures of modern painters which have been finished without much regard to the artist's real powers in order to provide money to make the pot boil.] "The proof of the pudding is in the eating," was here interposed by one of the members of the Cleikum Club, and with this observation I may conclude my extracts from this entertaining lecture. The great authority of early English cookery is the 'Forme of Cure,' composed about A.D. 1390, by the Master Cooks of Richard II., which was published in 1780, by that able antiquary, Mr. Pegge.—('Ency. Met.')

The word cookery is derived from the Latin *coquo*, and means to bake, roast, boil, &c. It also comprises the preservation of food otherwise than by the action of fire, as, for instance, where dry beef, or fish, or fruit, has been obtained by the heat of the sun.

You may take drying in the sun to have been the most original form of cooking, as fire has not been always universally known. When it became known to man, and acquired the title of one of the elements, roasting first before it, or grilling food on it, or baking underneath its ashes probably followed, and the use of hot water could only have obtained when vessels or utensils capable of containing water and resisting fire came to be manufactured.

In cooking, we have to appeal to the senses to aid us, and the variation in the performances of cooks may be due to the fact that all have not at one and the same time, in the greatest conditions of perfection, eyes to see with, touch to feel, a sense of smell, or a perfect taste—for all these are required.

More than that, the cook may easily be misled by the quality of the compounds or ingredients to be dealt with.

The following observations, by a man of great talent, exemplify this:—

"It is well to be particular in receipts; but it is idle to put out of sight the fact that particulars vary every day, in every country, and in every household—the sugar of England is a good deal sweeter than the sugar of France—the salt of France is much more salt than that of England. The quantities to be used, therefore, must continually vary. Again, everybody knows that vegetables are not alike in flavour; some apples are comparatively tasteless, so are some carrots, and one lemon is sharper than another. Therefore in one kitchen a lemon, an apple, or a couple of carrots, will go further to flavour a sauce than double the number in another kitchen. Carême praised the beef of England, he said it was perfectly beautiful, tender, delicious to taste, pleasant to behold, but he also said that it wanted

the unctuosity of the French beef, and would not lend itself to sauces and rich *consommés* without using up far more than would be required in France. What does this mean, but that quantities of beef used for soup in one country will not do for the same soup in another country. It depends on the butcher. It is the same with ham—the flavour of which is not to be measured by weight—a hundred pounds of French ham will not yield the flavour contained in ten pounds of Spanish, German, or English hams. It would be easy to multiply such examples, showing that quantities are deceptive, because they are unintelligible apart from quality."—(*Dallas.*)

Some remarks of an apologetic character may not be out of place in this introduction.

When we use the word "principles," we assume a certain possession of scientific data on which these "principles" are based. Unfortunately, and here the apology comes in, the refinements attending the best knowledge of the "principles" are so multiple that, according to present lights, a good practical cook with taste would beat the finest theoretical *chef*, who confined himself to weights and measures in food, fire, and utensils, and in whom the necessary good taste might be absent.

Here and there we may find the observations of a scientific man, like Mr. Mattieu Williams, whom I have freely quoted, of the greatest importance as proving the why and the wherefore of certain principles; but, infallibly, we must recognise that Science is now and again to be left alone, and an appeal made to her handmaid, Art.

So much for the difficulty of laying down the "Principles of Cooking" on a purely scientific basis, and, this apology made, I may proceed with my work, but I wish to insist very specially that no one, male or female, working for wage or working for love, need ever proceed to practice in the kitchen until he or she has mastered the great and essential difference between BOILING and SIMMERING. In that lies the major part to be played in spoiling or improving the food committed to his or her care.

Holding, as I have done, very strong convictions on most points connected with household cookery, and, without any leaning to what is called the French school, except for so much as is good in it, I have, of course, had to apply on technical points to experts and authorities. Rarely, indeed, have I found those I deemed the best of them to differ from each other, although, I admit, that on the question of closing the stock-pot I could get no unanimous opinion. I have made it my rule to quote my authority where I have adopted the said authority entirely.

I particularly desire to recognise the value of Mrs. Reeve's 'Cookery and House-keeping' (Longmans), from which I have extracted observations on the defects of English cookery, which repeat in greater detail the views I expressed some years ago.*

THE ELEMENTS OF COOKING.

Those things which mainly assist us in the art and science of cooking may be said to be :—

A. Food (animal and vegetable) and liquid (generally water, but sometimes fat or oil, wine, and vinegar).

B. Fire.

C. The utensils in which we place, or by which we apply the food to the action of heat.

Yet this will not be correct unless I point out the exceptions to the rule of using fire. Of course where oysters, &c., are eaten raw, or where we indulge in fresh fruit, no process of cooking intervenes. The same cannot be said if you prepare a salad with oil and vinegar, &c. It is true it is called preparing, but, effectively, it is cooking in a cold form, and requires as much attention as other methods where heat is employed.

In other Handbooks issued by the Executive Council the reader will find most that is to be said on the character

* Article "The Kitchen and the Cellar" (*Quarterly Review*, No. 286, 1877), now re-published in my work, 'A Scratch Team of Essays.'

of A, Food,* and the Reports of the Jurors will enlighten the public on the merits of the latest forms of ranges, &c., made to assist us in utilising B, Fire. But C, the utensils we employ, demand particular attention from me, for on their shape, make, material, and cleanliness, the success of the cook's work will very much depend.

Utensils, then, will be my first study; then the verbs which we employ in cooking, and their illustration.

UTENSILS.

If I give you a list, as near as may be, of all possible kitchen requisites, it by no means follows that they are to be desired by all sorts and conditions of mankind. I shall afterwards accentuate the more important, and I will only italicize here those without which it is difficult to carry on the most modest operations:—

Ice-mould, ice-pudding mould, *spice-box*, pepper-mill, *pestle and mortar*, baking-sheet, *dish-covers*, freezing-machine, turbot-kettle, *fish-kettle*, *dripping-pan and ladle*, *preserving-pans*, *gravy-strainers*, *egg-whisk*, frying-basket, salamander, Bain-Marie pan, *jelly-bag* and stand, *seasoning-box*, *omelette-pan*, cutlet-pan, *cooks' knives*, pallet-knife, *kitchen-fork*, *copper stew-pans*, *stock-pot*, *iron saucepans* (*enamelled*), boiler, braizing-pan, *frying-pan*, *colander*, *Yorkshire-pudding tins*, copper-moulds, tin-moulds, border-moulds, *larding-needles*, *trussing-needles*, *skewers*, *saw*, *chopper*, cutlet-bat, *paste-board*,

* On the other hand, it is not an unfair thing for the compiler of this Handbook to insist that the English cook is unfairly handicapped by the market-gardener. All the principles in the world will not enable the cook to make vegetables appear and taste fresh that a gardener, who only consults his own convenience or that of the market, sends in twenty-four hours before the proper time. The anti-scorbutic properties of the vegetables may remain, but their fresh garden flavour will have disappeared, and, as I have said elsewhere in the article already mentioned, we want in cooking to extract the subtle essence of the garden and present it in the dining-room.

Always admitting that you must afford proper time for the cook to clean them, the later vegetables are gathered the better.

rolling-pin, *flour-tub*, *weights and scales*, *liquid-measure*, *mincing-knife*, *mincing-machine*, *wire-sieves*, *hair-sieves*, tamis-bats, *tamis-cloths*, *wooden spoons*, *iron spoons* (galvanised), French cutters, *paste-cutters*, paste-brushes, biscuit-pricker, *patty-pans*, *tea-kettles*, *toasting-fork*, *gridirons* (if you grill fish, 2), *washing-up tubs*, *wooden pails*, *zinc or galvanised-iron pail*, 4-gallon iron saucepan, 2-gallon ditto, *tin egg-saucepan*, iron stew-pan, *quart enamelled-iron saucepan*, pint ditto, 2-quart milk-can (with cover), *flour dredger*, *pepper-dredger*, *nutmeg-grater*, *trivets*, *chopping-board*, *hatchet* (for breaking bones); thick oak board, for cutting up meat; *salt-box*, egg-basket, *wire salad-basket*, *pudding-basins*, *pie-dishes*, *pastry-basin*, *vegetable-pan*, *bread-pan with cover*, iron digester-pot (3 gallons), *block-tin cake-mould*, block-tin raised pie-mould, wrought-iron omelette-pan, cradle-spit, *oval boiling-pot*, *meat-screen*, *bottle-jack*, root-knife, *Dutch-oven*, *saucepan with steamer*, *box of vegetable-cutters*, *fish-slice*, *egg-slice*, box of pastry-cutters, *bread-grater*, *vegetable-scoop*, *tin funnel*, *gravy-strainer*, tartlet-pans, tinned meat-hooks, cork-screw, thermometer, washing-bowl, cinder-shovel, *coffee-mill*, coffee-roaster with clockwork action, refrigerator.

Of the above many are required not only in duplicate and in one size, but in larger numbers and dimensions.

I will now proceed to describe the most necessary of these.

Scales and Measures.

These are an absolute necessity in any well-ordered kitchen. You must be precise in checking any possible errors on the part of the tradesman who has supplied you, and you must be precise in the proportion of the various articles of food that are to enter into combination under your auspices.

Measures, by which I mean liquid measures, are also desirable. Above all things, take care that your weights have their exact place, from which there is no deviation. Have paper always at hand in a drawer, which you may

place on the scales when you have to weigh fatty or greasy substances. Your time, or that of your kitchen-maid, ought not to be passed in keeping your scales bright. Rather let the labour of the elbow, combined with the proper lubricant, be bestowed on those copper saucepans in which you ought to take a pride.

I shall add to the heading of each utensil the verb in cooking to which it is allied.

As to the relative value of liquid measures, you may take it as a rule, for practical purposes, that—

30 drops = a teaspoonful.
4 teaspoonfuls = 1 table-spoonful.
4 table-spoonfuls = 2 fluid ounces = one-eighth of a pint = a wine-glass (a very indefinite measure in its own name, but one which we can only recognise in this manner).

1 large table-spoonful of flour ..		=	½ ounce
1 table-spoonful of salt, brown sugar, &c		=	1 ,,
1 hen's egg	(about)	=	2 ounces
1 apple	(about)	=	3 ,,
1 pint of bread crumbs ..	(about)	=	8 ,,
1 pint of flour, sugar, &c.		=	1 lb.
A quartern or ½ gallon		=	3½ lbs.
A peck or stone		=	14 ,,

A gill is ¼ pint.

The Kitchener, or Modern Kitchen Range

I shall have again to refer more particularly to the modern kitchener when I treat of roasting and boiling. It may be sufficient to point out here that its introduction has placed our cooks in a better position with regard to the possibility of cleanliness, and also with regard to the proper regulation of the heat, to say nothing of the economy of fuel; in fact it brings the English cook more on a par with her French rival, who works with charcoal. A writer, for whose views on the subject of cooking I have a great respect, says, "It can hardly be doubted that in past ages, when English cooking vessels were made of copper, like those of most foreign countries in the present day, and charcoal was the ordinary kitchen fuel, this country had

much the same style of victuals as the rest of the civilized world. The introduction of iron pots and pit-coal firing has largely to answer for the sorry pass to which the culinary art has come here." Of course, the writer referred more particularly to pit-coal firing in open ranges.

For the same reasons, economy of heat and cleanliness, gas-stoves are much to be commended, and the existence of one or two jets in combination with the usual kitchener is of great value where you want to have your stock-pots constantly at work.

On this Mrs. Reeve says: "The best grate or hot-plate for cooking purposes has yet to be devised. The old-fashioned open-range roasts admirably, but it does everything else very badly. A hot-plate, or gas-rings, or charcoal fires in a hot-plate, must exist in every kitchen where there is to be varied cookery."

The Boiling or Simmering Pot (Verbs—To boil or simmer).

This is a large iron pot, tinned inside, with a cover. It contains from 2 to 5 gallons and upwards. There are puddings where you will use it for boiling. There are pieces of meat where the simmering process will come in.

The Frying-pan.

Of all the utensils of the kitchen, this is the most common, the most world-pervading, and yet is constructed in defiance of the rules that govern the process of frying.

The frying-pan of commerce—I mean by that what you can buy at the ordinary ironmonger's—is never deep enough.

A false economy is invariably practised in the matter of the fat, which should completely cover most articles to be fried, and, when used, be strained off into hot water. I mean by this that because I advocate a deep frying-pan, which will enable you to fry, say, a sole without turning it over, I do not necessarily advocate extravagance. Fat

should always be fit for use several times. This will be more fully enlarged on when we come to the process of frying.

There should be in every kitchen a fish frying-pan, with drainer or wire lining, by which you can take out your fish without risk of breaking it. This frying-pan should be 5 or 6 inches deep.

For omelettes, &c., a special pan is better.

Dr. Mitchell complains that the sides of our frying-pans are too perpendicular, and not convenient for making an omelette. I did not think that that was one of their faults, but rather want of depth. Doubtless, for omelette-making you want a special frying-pan. But even here the cook's skill in making the omelette mixture has as much to do with the result.

Sauce or Stew Pans (Verbs—To simmer, to stew, and sometimes to boil).

If you can possibly afford it (and, owing to the fall in the value of the metal, they have lessened in price), you should always have copper stewpans, as well as other saucepans, in your kitchen. Three, varying from a pint to two quarts, will satisfy the wants of a modest household. These stewpans are tin-lined, and require at various periods, according to their service, to be re-tinned. Otherwise very serious results, in the form of poisoning, may result.

Iron saucepans, lined with enamel, or simply tinned, are chiefly of use where the food you cook in them is to be subject to absolute boiling. Such is the case with the plain potato or other vegetable, or, say, puddings; but when you have simmering to do, appeal to your copper pan to aid you. Or, again, have a double saucepan, similar in principle to a bain-marie, where a small saucepan, lined with enamel, fits into a larger one, in which you have the water. Under the verb "to stew," you will see where the utility of this may be found.

The Stock-pot (Verbs—To simmer, to stew).

You will, if your means afford it, have two of these, one with a cock to draw off the liquor; and, as I have pointed out under the head of kitchener, it would be a great advantage if every range had gas laid on, so that either of these utensils, or both, might be placed over one or more jets, to carry on economically the processes for which they are intended. I have not dwelt on the old digester, as modern *chefs* seem to have discarded it, for reasons connected with the great question of whether you should or should not keep your cover on. See under the head of "Stewing," below. One of your stock-pots may very well be of EARTHENWARE; and it is singular that the West Indian practice of having a standing pepper-pot from which a meal can always be obtained, has never got a footing in this country. In Baron Brisse's French work, 'Household Cookery,' he says, "never mind what any one says, I still maintain that the best bouillon is to be made in earthenware."

The West Indian pepper-pot named above is made in a large pipkin of very singular and (at first) friable material. I learn that it hardens by usage, and that a pot will continue in constant use through two or three generations. As I remark below, under the head of made dishes, it is a pity we cannot have some national dish cooked in some such vessel always on the hot-plate, always ready to afford the guest a palatable meal.

The Gridiron (Verb—To grill or broil).

This article does not require description. The substitution of fluted bars and a gravy-trough for the ordinary iron bars is undoubtedly an advantage. The legs nearer the handle should be shorter than the legs farther from the cook, because the fat will then flow down the grooves away from the fire.

The Fish Kettle.

You may have this in different metals, according to your purse

Salamander (Verb—To brown).

An iron which you heat red-hot, and with which you brown macaroni, &c., that are thereby improved in taste and appearance.

Pestle and Mortar.

Very necessary, in households even of moderate means.

Salad Bowls.

These should be in two or more sizes. Their interior should form a perfect half-circle or hemisphere.

Braising Pan (Verb—To braise).

This is a pan with a hollow lid to contain hot coals or hot water. As the braising-pan must not be too large for the piece of meat to be braised, it is desirable to have hollow lids to more than one size of stewpan. (REEVE.)

Bain Marie.

A hot water-bath in which to place sauce and stewpans.

Meat Screen—Roasters (Verb—To roast).

You know the ordinary meat-screen, and it is unnecessary to illustrate or dwell on it. Much having been said about the difficulty, now that smoke-jacks are out of date, of roasting meat horizontally, I bethought me that it would not be difficult to devise a jack and spit, and dripping-pan in connection with a meat-screen. I had just completed my plans when I found that I had been anticipated by a manufacturer, and that you can buy such a thing, under the name of the Veruvolver.

I am not sure but what some ventilation might with advantage be applied in this case to the meat-screen, and my original idea was to have the dripping-pan and spit in front of it, and only the machinery for turning placed at *the side*. No doubt there would be some technical diffi-

culties in the way of this, and we may find ourselves obliged to have the spit and pan inside the screen. I grudge the loss of the oxygen with which meat roasted in the ordinary way is supplied, and I therefore think that, as in the oven, if we roast our meat in an enclosed space, we must take care to have that space ventilated.

It has not been thought necessary to give illustrations of all these, because any ironmonger's catalogue will show you to what I have referred.

THE VERBS OF COOKING.

It may seem to some that I write of very elementary principles, which every school-board child should know, when I ask you to follow me in defining what the verbs are which represent certain processes of cooking.

But truth and accuracy are the first elements in any science, and if I show you that verbs are employed which do not represent facts, you will become convinced that it is not idly that I ask you to pay attention to this elementary provision.

I will give you as an example of possible inaccuracy, the immortal description in one of Dickens's novels, of the boiled leg of mutton and trimmings called a swarry, which was to satisfy the longings for food of a select band of Bath footmen.

I say possible inaccuracy, because it may have been that these gentlemen were satisfied with very hard meat, and hard meat they would have had if they got a *boiled* leg of mutton. I do not think they would have been satisfied, and I do not think the novelist meant that they should have had set before them otherwise than a decent dish.

But the novelist adopted the current and misleading phrase "boiled," when what the mutton underwent or should have undergone, was the process of "*simmering*."

I have laid some stress on this in my brief introduction,

because more food is spoiled throughout the empire by mistaking boiling for simmering, than by any of the other processes by which cooks destroy food and torture the persons who are to eat it.

Let me define here what that which is *called* a boiled leg of mutton properly cooked is *not*—it is not boiled in any sense of the word. You bring your water fully to boiling-point before you plunge in the leg, but the meat itself whilst being closed in its pores by the action of the boiling-water reduces that water immediately in temperature, and if you are wise you will never allow that to rise again to boiling-point. For the rest of the time, during which it is in the pot, it remains at a simmering temperature.

Almost all cookery-books require re-editing in respect to this expression "boiling," the word being most frequently used where nothing more than "simmering" is meant.

In the same way, in consequence of the advent of the kitchener, we are gradually getting to the use of the word "roast," where in reality we mean the process of "baking." The distinction is not of the same lasting importance, because you do not absolutely spoil food where you use the oven instead of the spit. In the case of boiling versus simmering, you do spoil the food and make it hard, and by the misuse of a verb you bring up two or three generations to a slipshod habit of using a verb which does not represent fact.

Our verbs in cooking may be said to be to Roast, to Bake, to Grill, Broil or Toast. These last are synonymous, as shown by the French verb *griller*. *Pain grillé* is toasted bread, which we shorten into "toast," although we might in accuracy just as well call bacon done in a Dutch oven "toast." To Fry, to Boil, to Simmer, to Stew (soups, sauces, &c.), to Braise, to Baste, to Brown, to Clarify, to Reduce. To *Sauter* (here we use a French verb, because we have no equivalent to represent the process. Literally, it is to "toss," effectively), to Fry lightly, to Flavour, to Strain, to Sweeten, to Roll, to Knead, to Mix, to Stir, to

core, *e.g.* to take out the core of an apple or pear. To Peel, to Butter, *e.g.* to line a mould with a thin layer of butter, to Skim, to Reduce, to Scald, to Dress, to Brown or Colour, to Serve.

Of these verbs the following comprehend the elementary principles on the successful realisation of which your cooking will be good or the reverse. Roast, Bake, Grill, Fry, Boil, Simmer, Stew, *Sauter*, Flavour, Clarify, Clean, Brown ; and serve.

The illustration of these verbs may well be preceded by some observations from the pen of a scientific man—Dr. Youmans, illustrating the action of heat upon meat—even although I may have to repeat in a different form elsewhere the substance of what he says.

"If the pure fibrine of meat is exposed to a moderate heat, it parts with a large portion of its water, which it held like a sponge, and loses the power of taking it up again. It consequently shrivels and shrinks. If the heat be carried high, further decomposition and charring takes place. The effect of boiling upon fibrine is not to make it more tender, but to increase the hardness and toughness A low degree of heat changes liquid *albumen* to the solid condition, altering remarkably all its physical properties. It neither dissolves in water, hot nor cold, and is impenetrable to it. If diffused through one or two hundred times its weight of water, it coagulates, forming fine fibrous meshes throughout the liquid sufficient to entangle any mechanical substances that may be floating in it, and bring them to the surface or carry them to the bottom. In this way albumen is used as a clarifying agent. If its proportion be much larger, the entire water may combine with it and pass into the solid state. The egg for example, contains 74 per cent. of water, and 10 of oil. Yet its contents are all solidified by boiling, through the action of 14 per cent. of pure albumen."

It will also be useful for you to retain in your memory the general loss that takes place in beef and mutton in the processes of cooking. Thereby you may check roughly the

quantity of cooked meat that passes through the kitchen either on its way to the dining-room, and its consumption there, or which may be honestly used for promoting health and well-being among the domestics, or less honestly bestowed on guests of the kitchen to whom you have not sent out letters of invitation—

LOSS OF WEIGHT.

	In Boiling.	In Baking.	In Roasting.
	lb. oz.	lb. oz.	lb. oz.
4 lbs. beef lose	1 0	1 3	1 5
" " mutton lose	0 14	1 4	1 6

CHOICE AND PRESERVATION OF MEATS, FISH, &c.

Of course you must have some Principles in selecting meat, game, fish, &c., as you have in cooking them. I will give you some brief rules:—

For Beef.—Let the flesh have a smooth open grain, and a good red—the fat rather white than yellow. Ox-beef is the best. In old meat a streak of horn runs between the fat and the lean of the sirloin and ribs; the harder, the older.

Mutton.—Fineness of grain and firm white fat are the chief good characteristics.

Pork.—A thin rind is a great merit.

Venison.—If the fat be clear, bright, and thick, and the cleft of the haunch smooth and close, it is young; but if the cleft is wide and tough, it is old. To judge of its sweetness, run a narrow knife into the shoulder or haunch, and you will know by the scent. It bears keeping better than other meats, and if eaten fresh is not so good as mutton.

In that curious work, 'A Country Housewife,' by R. Bradley, Professor of Botany in the University of Cambridge, and F.R.S. (London, 1732), he says:—

"Sometimes venison (meaning a buck) comes up to London not fit for the table; to prevent which, order the

keeper, when he has killed it, to strew three or four pounds of pepper, beaten fine, upon it; and especially upon the neck-parts of the sides, after he has washed them with vinegar and dried them well.

"But if it stinks when you receive it, wash it with vinegar and dry it; then pepper it and wrap it in a dry cloth, bury it in the ground three feet deep at least, and in sixteen hours it will be sweet, fit for eating; then wash off the pepper with vinegar and dry it with a cloth, and hang it where the cool air may pass and the blue-flies cannot come at it."

To keep Game from tainting.

When you have drawn and washed your birds with soda and water, and well rinsed and wiped them, rub in lightly salt and black pepper. Then put in the cavity of each bird a piece of charcoal, and hang in a cool place with a cloth over them. (*Reeve.*)

The following remarks on refrigerated meat come to me from a firm in Leadenhall Market that deals most largely in this business, and that in a retail form. As this kind of food is likely to be more and more used among us, you will take note of what they say:—

"New Zealand mutton is frozen mutton, as hard as a stone when we receive it, and should be treated as fresh-slaughtered meat. It should not be cooked till it has hung in the larder several days to get the frost thoroughly out and to make it eat more mellow. This process causes the meat to get a little discoloured, but adds greatly to the flavour. (This specially refers to the legs, loin, and shoulders.)

"But should the meat be required for immediate use then it should be thawed by placing it in front of the fire for about one hour and a half before putting it down to cook; but it is far better to thaw it gradually, as above stated."

Turkey.—If young, smooth black legs (the cock with a short spur). If fresh, eyes full and bright, feet supple and moist. If old, eyes sunk, feet dry, and legs red and rough.

Fowls.—If a cock, spurs short, but see that they have not been cut or pared to deceive the buyer. Comb of a cock bright and red. Vent close and dark. Black-legged fowls to be preferred for roasting.

Geese.—Bill and feet yellow, if young; if old, red; if fresh, feet pliable; if stale, dry and stiff. Choose them thick in the breast, moderately fat, and the fat of a good colour.

Ducks.—Same rules as for geese. Tame ducks have thick feet and of a dusky yellow. Wild ones, feet reddish and smaller.

Pigeons.—The feet should be supple. (The flesh of the wood-pigeon is dark-coloured, and if properly kept, is equal to teal.)

Hare or Rabbit.—Look at the claws, ears, and haunch. If blunt, dry, and thick, it is old. If claws are sharp, ear easily tears, and cleft in lip not much spread, the animal is young. A leveret will be known by a small bone near the foot on fore-legs.

Partridges.—Try the bill. If soft, young; if hard, an old bird. Same for grouse.

Pheasants.—Cocks by preference, with short blunt spurs.

Fish.

The following observations are extracted from the 'International Fish-Cooking Book,' by the author of 'Facts and Hints for Every-day Life,' published last year. By attention to them the cook will be on the road to success.

Selecting Fish.

The most reliable signs of freshness in fish of every kind is the brightness and prominence of the eyes, and the

redness and rigidity of the gills. Fish which is unseasonable will display a want of solidity and firmness, with a blueish pearly appearance where it should be white. Salmon, mackerel, herrings, carp, tench, and trout rapidly lose freshness, flat fish preserves it longer, skate and turbot require to be kept for a day to attain perfection as food.

Preserving Fish.

Fish, except in frosty weather, will not keep more than two or three days. Those that are to be kept should have their intestines removed directly they are caught. Never salt soles. Turbot, if lightly rubbed with salt and kept in a cool place, will keep well for two or three days. Eels should be bought alive.

Fish will keep good several days, if treated in the following way:—Put into a saucepan three quarts of spring water, a pint of good vinegar, and a spoonful of salt. When it boils put in the fish, and let it remain in two minutes, drain, hang in a cool place. Smelts and other small fish should remain in the boiling liquid only one minute, and when drained, hung up in small open wicker baskets, through which the air can readily pass.

Hints for the Cook.

Amongst trout that known as the silver trout is best in flavour. The harder the water, the better it is for boiling salmon. It is an important point in cooking fish to keep the vessels perfectly clean, particularly the fish-kettle, which should be warmed on the fire before cleansing finally, in order that any little pieces of cold fish and jelly, which are apt to adhere to the corners, may be melted and removed. It should smell perfectly fresh before use. Many a fine fish is spoilt by the neglect of such precautions. We mention in the following receipts the salamander. Those who have not this instrument may make a fire-shovel red-

hot, and hold it close to the preparation they wish to brown. Frying is a rather costly way of cooking fish, as it wastes the fat, which would make a sauce for them if boiled. However, the lard, if returned at once to the basin, may be used a second time. The grand secret, we may add, of successful frying is to have sufficient fat boiling, before the fish is placed in the frying-pan, to cover it. Butter is substituted for lard sometimes, but it does not improve the colour of the fish, and on the Continent oil is used, which is expensive. Clarified dripping is very good for this purpose. Fish should be cleaned by the fishmonger. To remove the earthy flavour which pond fish has, when the fish is carefully cleaned insert in place of the removed interior a piece of bread to fill the vacuum closely. This is removed after the fish is cooked.

So long as you are in a large town, trussing is of no importance, as your poultryman will always truss any game you may have sent you. But should you be in a country district, or in the Highlands with friends about you shooting down game, it will be essential for you to know how to truss.

The process is too long to describe here in all its branches, and so I will refer you to Mrs. Acton's book.

SALTED MEAT.

In what way salting injures meat, as it undoubtedly does, is not, I believe, known in a perfectly scientific manner, but as the most influential constituents of meat are dissolved in its juice, it may be taken that the salt abstracts the juice with its albumen, kreatine, and valuable salts; for we find that the brine contains the chief soup-forming elements of meat.

TO ROAST AND TO BAKE.

(*See again* To Bake.)

Strictly speaking, these two "Principles" should be separated and dealt with on their distinctive merits. But the extended introduction of kitcheners in place of the old open range have brought us in face of the fact that much food that was formerly roasted goes into the oven. Owing to the increased ventilation that is now given to the contents of the modern oven, a joint cooked in it does not present the decidedly baked flavour that obtained when the process first came into use. The economy and the cleanliness associated with the kitchener are so great, that no one would place the open range in comparison with it for other purposes than roasting. Yet it does not follow that I am to advise you to eschew roasting and commit your joint to the oven. No oven, I contend, has yet been constructed that will turn out a baked joint of meat equal in flavour to what the same joint would have had if cooked with the old-fashioned jack in front of the fire. "What are you to do?" will be your question. The answer is simple. Let the open fire of the kitchener have a larger surface-area, place in front of it thinner bars than those ordinarily supplied, and effect the necessary economy in fuel by having a moveable grating in the fire-place, which may contract it when roasting is not to be performed. It is the condensed vapour in the oven, of which you cannot entirely get rid, that affects the fatty part of a joint and causes it to be less crisp. A writer whom I have already quoted, Dr. Mitchell, of London and Paris, says on this subject of roasting, "Even the boasted English roast is no longer what it was in the days when few households were without the pulley-jack and horizontal spit. The deterioration set in with the introduction of the bottle-jack and vertical roasting, and has been intensified by the kitchener with its stuffy empy-

reumatic oven." You see by this language what very positive views a competent judge holds as to the impossibility of making an oven do the work of the open fire, and I ask you, in the interests of good cooking, never to listen to what interested dealers in ranges may tell you. An open fire and a horizontal spit (see Utensils) are quite possible adjuncts to a modern kitchener, and if you insist upon them they will be supplied. I do not say that this horizontal spit is to be found at every ironmonger's, but I have shown that the motive-power can be applied at the side of an ordinary meat-screen to the horizontal spit, on the value of which, for roasting purposes, Dr. Mitchell very properly insists.

At the same time, let me appreciate at its true value the oven in a modern kitchener for poor people who cannot afford a jack. Yet even with an oven the basting should not be dispensed with ; and as you have to open your oven for the purposes of turning the meat, so you may avail yourself of the same opportunity for basting, taking care to open and close the door gently.

If we reflect for one moment on the difference between the coffee-berry in its simple state and the flavour produced by roasting, we shall realise what the action of fire may do in developing a hidden fragrance.

You will see under the head of Boiling and Simmering how a crust or shell is formed by a proper process, within which the sapid constituents of the meat are retained, rendering it juicy and well-flavoured. So it is in roasting or baking; for whether the meat be surrounded by water or in an oven, or before the fire, so soon as the waterproof coating is formed around it, the further changes are effected alike in both cases by internal vapour or steam. In roasting or baking, therefore, the fire should be at first made very hot, until the surface-pores are completely plugged and the albuminous crust is formed.

As a broad rule, you may take fifteen minutes to the pound for beef and mutton, and seventeen to twenty

minutes to the pound for pork and veal. Mrs. Reeve gives the following :—

Time Table for Roasting at an Open Fire.

10 lbs. of beef	require	2½	hours
5 „ „	„	1¼	„
6 „ leg of mutton	„	1½	„
Quarter of lamb	requires	1	hour
Leg of lamb	„	¾	„
4 lbs. of veal	require	2	hours
4 „ pork	„	2	„
Hare	requires	1½	„
Leveret	„	¾	hour
Turkey	„	1½	hours
Fowl	„	¾	hour
Goose	„	1¼	hours
Duck	„	¾	hour
Pheasant	„	¾	„
Partridge	„	½	„

In roasting small birds, you will take care to bear in mind the important factor, time. From a quarter of an hour to twenty minutes is generally sufficient for a small bird. For venison the time will be much the same as for meat, according to size.

TO BAKE.

Of all the food which passes through the oven, bread, the staff of life, is the principal. The fact that it is universally made for our use, and very rarely comes to our table from our own oven, renders it unnecessary to describe at length the process through which it passes. But you may possibly find recommended in some of the reports connected with this Health Exhibition the use of whole-meal bread, and you may find it difficult to get yourself supplied with it. If this be the case, and you find yourself compelled to make the whole-meal flour into bread in your own kitchen, the following directions may be of value to you :—Take half a quartern, or 1¾ lbs., of dry whole meal; 1½ pints good measure of half milk and half water, which should be tepid;

1 ounce of fresh German yeast; 1 pinch of salt. Mix the yeast with half a pint of the liquid smoothly into a cream; stir this into the flour with a wooden spoon, and add the remainder of the liquid when thoroughly mixed. Knead it well, and put it into a tin properly buttered. Set it near the fire for *twenty minutes, and then bake* in a moderate oven about one hour. Turn it at the half hour gently, so that each side in turn shall get the greater heat, and do not slam the oven door.

The difference between this process and that of making white bread, is to be found in the above italics; *i.e.* white bread would be placed before the fire for an hour or upwards before you arrived at the process of kneading, whereas the whole time employed in making a loaf of whole-meal bread may be comprised in thirty minutes.

There are some things, such as *soufflés*, which can only be supplied in an eatable form by proceeding direct from the pan to the dining-room. I recollect the *chef* to a Russian nobleman telling me a story about these. His master was a *gourmet*, but sometimes had personages as guests who were liable to be unpunctual. On these occasions he would proceed to make *soufflé* after *soufflé* until the appointed time came for the dish to be eaten. He was a *chef* who considered his reputation would have gone for ever if he had served a *soufflé* that had passed the first and only rise.

Ovens differ much even if constructed on the same basis. It is of great importance that you should study your oven. You can regulate the heat of an oven by putting in a tin plate at times to absorb extra heat. In baking meat take care to baste at intervals. See above, to Roast.

Take the precaution not to make a pie too large for your oven, as the Strasbourg pastry-cook did, who was ordered to supply a German personage with an enormous *paté*.

TO GRILL, OR TOAST, OR BROIL.

This is a process where you cook by radiation. You fail without a clear bright fire, and the utensil you employ is quite a secondary consideration. As in roasting, you form a crust on the outside of your steak or chop, and seal the juices within. The time you employ is purely a matter of taste for the person who is to eat it.

In the case of toasted bread it is essential that you should begin by presenting the surface of the bread five or six inches from the fire, approaching each side gradually. You will then obtain crisp toast, and you must serve it in a rack. It is peculiarly an English *plat*, and is scarcely met with on the Continent, except when ordered.

If by the conditions of your range* you are able to indulge in grilling without the flavour of coal smoke, remember that many fish grill well, and that for them you must have a separate and exclusive gridiron, which is sometimes chalked instead of greased.

You may also have a double gridiron, by which the chop can be turned without touching it, but a pair of tongs is the proper implement for moving a chop or steak.

TO FRY, ALSO TO *SAUTER*.

"Good frying is, in fact, boiling in fat," says Dr. Kitchener; but Dallas, perhaps more scientifically correct, allies the process to roasting. There is no question that the greatest French cooks have included an article fried under the head of *rôti*. Still, after this explanation, it will be better to confine ourselves to our national definition. We are not, at any rate, in the singular difficulty where the cooking books, directing us to "boil" when they mean, or ought to mean, to "simmer," have landed us. The following is one of the leading principles in frying most things.

* I am happy to say that I have at last seen one at this Exhibition.

Fry in boiling fat, and with a lively fire. Do not fry some time before you are going to serve, but time the operation so that you may serve direct from the pan to the table, allowing for draining off the fat. The smallest delay lessens success, for it permits the article fried to lose its crispness, and to become flabby. To this there is no exception.

You use dripping, lard, butter, and oil when you can afford and can get the latter. If you have occasion to skim a broth in which vegetables form a part, take such skimmed fat or grease, and put it aside for frying certain special articles. The flavour which such fat has gained from the meat and vegetables of the broth adds a pleasant qualification for the palate in the case of frying certain things. In like manner, if you have a *pâté de foie gras*, preserve the fat on the top of it, as it is sure to have some delicate flavour of the truffle.

Except in the case of whitebait, lard, butter, or clarified dripping are preferable for frying. For whitebait, rendered beef fat is the best medium.

"Frying," says Mr. Mattieu Williams, "is one of the processes in which the heat is communicated by convection, the medium being hot fat instead of the hot water used in the so-called, and miscalled, 'boiling' of meat.

"I say 'when properly conducted,' because it is too often very improperly conducted in domestic kitchens. This is the case whenever fish, cutlets, &c., are fried on a merely greased plate of metal, such as a common frying-pan. Pancakes or omelettes may be thus fried, but no kind of fish or meat. These should be immersed in a bath of fat sufficiently deep to cover them completely. To those who have not reasoned out the subject, such complete immersion in so large a quantity of fat may appear likely to produce a very greasy result. The contrary is the case.

"Let us take, as an example, the frying of a sole. On immersing this in a bath of fat raised to a temperature above that of boiling water, a violent hissing and crackling noise ('frizzing') is heard. This is caused by a series of small explosions due to the sudden conversion of water

into steam. The water was originally on the surface and between and within the fibres of the flesh of the sole. The continual expansion of this water into vapour, and its outbursting, prevents the fat from penetrating the fish, so long as the temperature is maintained above 212°, and thus the substance of the sole is cooked by the steam of its own juices, and its outside browned by the superheated fat.

"Now, let us suppose that a merely greased plate, like the bottom of a frying-pan, is used. Only one side of the sole is cooked at first—the side in contact with the pan—therefore it must be turned to cook the other side. When thus turned, the side first cooked with its adhering fat is cooling; its steam is condensing between its fibres, and the fat gradually entering to supply the place of steam, while the other side is cooking. Thus it is more greasy than if rapidly withdrawn from the bath of hot fat, and then allowed to drain before the steam commences to condense.

"Here is a frying-kettle, exhibited by Mr. Burton, with a wire frame or grill, fitting the bottom. On this the fish is laid, and by this it is raised immediately it is cooked, and the fat drained away. A stew-pan, or any other suitable kind of kettle, may be used, if provided with the wire basket for lifting; or a frying-pan of the ordinary kind, if deep enough.

"Although the quantity of fat required for starting this kind of frying is considerable, the consumption at each operation is less than when the greased plate is used; the material of the fat bath can be used again and again with occasional clarifying by methods well understood in the kitchen, but the fat used for smearing the frying-pan is nearly all wasted by the overheating and carbonising of a portion of it. Of course, two or more supplies of fat are required, one for fish, another for cutlets, &c., and another for such delicacies as apple fritters, which especially require the fat bath."

The plunging food into fat heated to from 300° to 400° naturally creates round it the same crust of which we speak in boiling and roasting. You may obtain thermometers

registering up to 500° Fahr. As Dallas says, if you would realise the difference between frying and half-frying, consider what a frying-kettle will do *versus* a frying-pan, always supposing the kettle full of fat, and the pan half full, after the usual English system.

The following is a recipe for preparing dripping-fat for the purposes of frying, but it must be understood as not applying to fish, omelettes, or pancakes, which cannot be fried in fat too clear of any kind of foreign flavour :—

"Melt all the residues of fat you have with a leaf of sage, a little celery, and a couple of sliced onions. When the onion becomes coloured, strain the whole through a clean sieve and pot it ; well covered, it will keep a long time."

The Italians are the most scientific and artistic in the matter of frying. They call the result a *fritto*. One of their commonest dishes is the mixed *fritto*, composed of veal cutlets, calves' brains, sliced artichokes, potatoes in short thin strips, &c. The secret of the *fritto* is that all these component parts are first soaked in a batter, and this batter will vary in its ingredients according to the character of the component parts. Take the above, for instance. The batter will be composed of a quarter of a pound of flour, the yolk of an egg, a teaspoonful of vinegar or, better still, the juice of half a lemon, and from 10 to 20 drops of oil. [The rarity of good olive-oil does not encourage me to include this in an English recipe, but such is the Italian formula.] You beat these all together, adding a little water or beer or white wine, sufficient to make the batter liquid. You beat the white of the egg apart and to a foam, and add it to the batter at the last moment just as you are about to fry. We now go back to the component parts of this *fritto*, which you are going to put into the prepared batter. The calves' brains you will clean, skin, and rinse, or even boil for a few minutes before you fry them, and the same with sweetbread if that is to be your dish, and then leave them to cool. When cold cut into small pieces about the size of half a walnut. Soak them first in a little oil, salt, and vinegar. Then dry them

with a clean cloth and soak them in the batter, from which they are thrown into the boiling fat or butter and fried to a rich gold colour. When quite crisp, and if the required colour, take them out of the fat and lay them on clean white paper or cloth to absorb the fat.* Serve on a cloth.

Cutlets, on the other hand, only require to be soaked in batter previous to frying. Vegetables, whether artichokes, cauliflowers, &c., are partly boiled in salt and water before being fried. Potatoes are preferable not boiled, and they are cut into strips so as to fry more easily.

I have given this as an example from a country where frying is a *specialité.* You will imagine it to be very elaborate and to take a vast deal of time, but cooking is not to be done without trouble, and in reality this resolves itself into the question whether you have or whether you have not all your requisites in order and to hand. No Italian girl would make a difficulty about it. It is in details of the kind shown to be necessary here in making a simple *fritto* that English cooks are so deficient.

And now to the gravest of all the principles which affect the absolute act of frying.

It is not enough that your fat should be in a spitting or bubbling state. It is a heat beyond this that you require, and which you will best find out by throwing in a small piece of bread and testing whether it turns colour immediately. If you omit this precaution with regard to heat, and put in your food too soon, you will take it out sodden instead of crisp, and it will never become of a bright and golden colour. On the other hand, if you let the fat rise to too great a temperature before putting in the food, it will become black.

The required temperature varies from 380° to 400° Fahr., and as you will probably not test by a thermometer, you will find at first that your patience, with the best intentions, will be tried; potatoes requiring the severer, while a

* All fried articles require the fat to be absorbed in this manner.

sole will demand the lower, heat. Yet practice alone can teach you this.

Directly you have taken your *fritto* or fried food out of the fat, take care to remove the pan from the fire, otherwise the fat will burn.

In describing the frying-pan, I have suggested that greater depth should be given them—say quite five inches—and the fat in it should be at least half that in depth for the frying of most things. Omelettes, pancakes, &c., are of course excepted.

A good light by which to fry, as in the case of grilling, is a necessity.

Sauter means to toss. It is really to fry lightly as opposed to frying in such a temperature that you obtain a roasting effect. You use less fat, and by tossing you prevent burning, and mitigate the heat.

TO BOIL.

(*See also* To Simmer.)

As I have already said, the public are so accustomed to hear of boiled legs of mutton, &c., that I may be expected to treat of meat under this head.

Inasmuch as meat will sometimes go through this to an infinitesimal degree, I will show you by the light of science what that infinitesimal degree is. Dr. Youmans says:—"In preparing meat for the table we shall discover it to be most desirable that the ingredients of its juice should remain in it, and this will depend much upon the methods of culinary procedure. If the piece of meat be introduced into the water when *briskly boiling*, the albumen at its surface, and to a certain depth inward, is immediately coagulated; thus enclosing the mass in a crust or shell which neither permits its juice to flow out, nor the external water to penetrate within, to dissolve, dilute, and weaken it. The greater part of the sapid (palatable) constituents of the meat are thus retained, rendering it juicy and well-

flavoured. It should be boiled *for only a few minutes*, and then kept for some time at a temperature of from 158° to 165° Fahr."

The learned writer has based the above on experiments by Liebig, than whom we can have no higher authority. But can any one pretend to say that meat that has passed through such a process can, when placed on the table, present to us boiled provision?

I trow not. The most we can say is that a large joint of meat may be suffered to boil two minutes, whilst for small pieces of meat the act of plunging into boiling water will be sufficient for the coagulation of the albumen.

And again, let us reflect what the "few minutes" of the scientific man may mean. Cooks have not always their eye on the clock, and a "few minutes," in fact any minutes beyond the number (two) that I prescribe, may be lengthened into that very indefinite period which secures that the meat shall be hard and any chance of its internal parts being cooked in the lower temperature (158° to 165°) reduced to a minimum.

It would be an advantage if cooks would retain their proclivities for water at boiling point for the infusion of tea. How often do we hear "The water 'as boil'd, Mum," from the lips of one who would not hesitate to keep a leg of mutton in full boiling water for a couple of hours!

You may boil salmon, lobster, and crabs, with advantage, but salmon if large, should be placed in cold or tepid salt and water with a teaspoonful of vinegar in it. If small, it may go into the boiling water at once. For other fish see To Simmer. In all cases you will skim as you would do with meat. When done get it out of the water as fast as possible, and set the drainer diagonally on the kettle. If you want to keep it hot some time before serving, dip a napkin in the hot liquor and spread it over the fish.

You may boil puddings of all kinds also.

It is generally agreed that salt beef, salt pork, and salt fish, are not plunged into boiling water, but are put into cold water which gradually rises to the desired temperature.

Boiling Rice.

Rice, if put into cold water and on to a good fire, is cooked by the time the water reaches boiling-point. Not a moment longer should water surround it. But rapid draining and the heat of the fire should rob every grain of particles of moisture, and afford you what might be a much more popular dish if we only cooked it properly.

Vegetables.

Boiling is the most common way of treating vegetables in this country. In their case there is no question of letting the boiling water drop to a condition of simmering, for you cannot keep up the boil too unintermittently. They should also be served *at once.* You will therefore study how late before the service is required it will be safe for you to put them into the pot or saucepan.

But before you come to this, your vegetables have to be picked and cleaned. As they should be as fresh as possible, so you will discourage the gardener from gathering large quantities at a time. Wash your vegetables if they need it, not otherwise. To let them lie in water is to injure them. If washed, the washing should be done quickly. To remove dirt is not the only object, but to dislodge vermin, such as earwigs, slugs, &c. Put into your washing-bowl a lump of salt, fill up with cold water, and add sufficient hot to make it tepid. Very shortly the vermin will quit the leaves of their own accord. You will now be ready for boiling.

Let your boiling-water contain a proportion of salt of two ounces to the gallon, and if you use soda to maintain the colour of green vegetables let it not exceed the size of a hazel nut. Keep your water well boiling from the moment you insert your vegetables, press them beneath the water from time to time so as to cook equally, and at the moment they have become tender, take them out, drain and, if necessary, press them, and serve in hot dishes. It has been held that if you wish your vegetables (green) to be of

a good colour you will keep the lid wholly or partially off the pot. The objection to this, where the kitchen is near the living-rooms, is that an unpleasant odour will pervade the house ; but this obnoxious element you may obviate by placing a lump of bread, the size of a French billiard ball, in a *linen* bag, and inserting it in the pot. It will absorb the gases which cause the disagreeable odour, and you will even pour away the water into the sink without further inconvenience. The linen bag being thoroughly washed will serve again. I think that if the cook would take advantage of rain-water, when it can be had, and adopt the above bread-bag, there will be little occasion to use soda.

Of the two kinds of asparagus, the white and the green and the wholly green, the latter takes from 10 to 15 minutes, the former perhaps 30. Boil the water before you put in the asparagus, and boil it ever more. Add half an ounce of salt per quart of water. Keep the tops out of the water, and do not let them break off. Drain well before you serve the asparagus in an oval dish. It is the practice to lay them on toast. I never heard of any one eating the toast, and should prefer a clean napkin.

Remember that whilst the water in which green vegetables or potatoes have been boiled is only to be thrown away, that which has cooked asparagus, lentils, peas, beans, or haricots is nourishing, and may serve as a foundation for soups.

Eggs.

Considering that these are one of the most important articles of food we have, it is quite wonderful how indifferent we are to the accurate cooking of them.

Except for special and indigestible purposes of a salad or a pie, boiled eggs should present, when served, a yolk set and the white or albumen a jelly. To succeed in this you will do better to simmer your eggs, and I refer you to that verb. In my endeavour to keep your mind clear as to the distinction between food that can be boiled thoroughly and such as can only properly be said to undergo that process

for a bare minute or two, I give you a table here for the former (fish, vegetables, &c.), and refer you to the verb simmer for the latter (mutton, turkey, &c.).

TIME TABLE FOR BOILING.

Rumpsteak-pudding	3½ to 4 hours.
Greens—quick boiling	25 mins.
Cabbage	¾ to 1 hour.
Asparagus—green	15 mins.
" white	About 30 mins.
Artichokes (cold water at first) .	30 mins.
Green peas . (according to age)	15 to 30 mins.
Carrots	According to age.
Turnips (young)	15 to 20 mins.
French beans	15 to 20 mins.
Broccoli	15 to 20 mins.
Cauliflower	15 to 20 mins.
Brussels-sprouts	10 to 15 mins.
Parsnips	35 mins. to 1½ hours.
Spinach	12 to 15 mins.
Onions—whole	1 to 2 hours.
Lobster or crabs	20 mins. to ¾ of hour.
Salmon—boil quickly	10 mins. to the lb.

N.B.—Salt helps th scum to rise.

There is a good reason for boiling food where you desire to arrest fermentation and decay.

"The property of organic substances to pass into a state of fermentation and decay in contact with atmospheric air, and in consequence to transmit these states of change to other organised substances, *is annihilated in all cases without exception* by heating to the boiling point."—(*Liebig.*)

Under Simmering I shall again enlarge on the cooking of meat in water, with a crust of albumen coagulated around it, as distinguished from stewing or braising, where the water has never been allowed to get to boiling-point.

TO SIMMER.

(*See above,* To Boil.)

There is one simple reason for plunging meat into boiling water (212° Fahr.). By so doing the albumen coagulates, an envelope is formed which prevents the escape of the internal juice and excludes the water. This attained, the meat need only be kept in a temperature of from 158° to 165° to unite the best conditions for eating.—(*Liebig.*)

I insist, therefore, that it is misleading to use the term "boiled" to what is simmered, although we may still be remote from the process of stewing, which involves less water, and that never brought to boiling-point, a smaller pan, and a still less degree of heat.

Simmering Eggs.

Precisely the same principle of simmering may be applied to the cooking of an egg. Put it into a deep saucepan on the point of boiling, let it boil, take it off the fire immediately and let it stand on the side of the stove for five minutes from the time of first putting it in. So done, it will be hard nowhere and raw nowhere. An egg kept boiling at a galloping pace for the conventional three minutes and a half will have a fine hard crust of albumen (the white), but the yolk may possibly be raw.

The following observations by Mr. Mattieu Williams on the cooking of an egg still further bear out my contention in favour of simmering, as opposed to the boiling process.

"By the ordinary method of the three minutes' immersion in continually boiling water, the white of the egg becomes hard and indigestible before the yolk is fairly warmed, and half a minute too much, or half a minute too little, will nearly ruin the operation. Cockney cooks know very little concerning new-laid eggs, but farmhouse cooks are well aware that a new-laid egg demands nearly a

minute more of that sort of cookery than one of full London flavour.

"The proper mode, as I pointed out years ago, in my first book on Norway, is to place the egg in boiling water, then remove the saucepan from the fire altogether, and leave the egg in the water from ten minutes to a quarter of an hour.* About half a pint for one egg, three-quarters of a pint for two eggs, or a pint for four eggs, is the quantity demanded if the saucepan is well covered.

"The cold egg, or eggs, speedily reduce the temperature from 212° to near the cooking temperature, and before the egg is warmed throughout, it is quite down to 160°, so that it matters little whether it now remains five or ten minutes longer in the water. In making experiments with eggs, I have discovered that the temperature of coagulation of the yolk is lower than that of the white, and thus, if the egg is kept in water at 160° for a long time, the yolk may become harder than the white, the centre having time to become nearly as warm as the outside. But for this, the egg might be kept in the water at about 160° for an hour or two.

"I have here exhibited, by Mr. Burton, an apparatus specially constructed for the cooking of eggs. It is called an 'egg coddler.' Being made of bright metal, and well covered, the heat of the water is retained, and a smaller quantity than I have named is sufficient. The eggs are supported in a moveable frame, which can be taken out, carrying the eggs with it; nothing more is necessary than to place these on the breakfast table duly charged with eggs, fill it with boiling water about ten minutes before the attack on the breakfast is anticipated, and if this should be delayed ten minutes later, no serious mischief is done beyond; the eggs are not hard, and are still hot. Coddle your eggs, never boil them."

In cooking such a simple dish as porridge, the difference between boiling it sharp for ten minutes, which some cooks, forsooth! call cooking it, and simmering it gently

* NOTE.—Practical experience has convinced me that this is the only true way of cooking eggs in the shell, but I give them from eight to eleven minutes.—S. B.

for three-quarters of an hour, will prove to any one what an undeserved character this economical food has for being indigestible.

After a ham has been simmered, it is a great improvement to put it in a moderately warm oven, with a buttered paper over it, and bake for an hour. This is a Yorkshire custom, and a very good one.

TIME TABLE. (See also the Time Table for Boiling.)

(Those marked with a * are placed in cold water and allowed to come to a boiling point, and are then simmered. The rest are plunged into boiling water and then simmered.)

Round of beef	20 lbs.	5	hours
Aitchbone of beef	10 „	2¾	„
Brisket of beef	10 „	2¾	„
Ham	15 „	5	„
Leg of pork	8 „	3	„
Hand of pork	6 „	2½	„
Bacon	2 „	1½	„
Pig's cheek		2½	„
„ feet		3	„
Ox tongues, fresh		2½	„
„ „ salt (cold water at first)		3½	„
Leg of mutton	9 lbs.	2½	„
Neck „	7 „	2	„
Breast of Veal	7 „	2½	„
Knuckle	7 „	2½	„
*Calf's head, if skin on		3 to 4	„
* „ „ „ off		2½ to 3½	„
*Calves' feet		3 to 3½	hours
Turkey, large		2½	„
„ small		1½	„
Fowl		1 to 1½	„
Chicken		½ to ¾	hour
Partridge		½	„
Pigeon		½	„
*Turbot (15 lbs.)		35 to 40	mins.
*Cod's head and shoulders	(according to size)	40 to 60	„
Soles		6 to 12	„
Skate		12 to 20	„
Herrings		10	„
Mackerel		15 to 20	„
John Dory		10 to 20	„

Observe well the remarks on the salt and vinegar in the water for fish, under the head To Boil.

Count Rumford illustrates by a story the advantages of moderate heat in cooking fish. "In the seaport towns of the New England States in North America it has been a custom, time immemorial, among people of fashion to dine one day in the week (Saturday) on *salt fish;* and a long habit of preparing the same dish has, as might have been expected, led to very considerable improvements in the art of cooking it. I have often heard foreigners, who have assisted at these dinners, declare that they never tasted salt fish dressed in such perfection; and I well remember that the secret of cooking it is to keep it a great many hours in water that is *just scalding hot*, but which is never made actually to boil."

It is not always necessary that you should boil or simmer your food in plain salt and water.

There are methods, too little understood with us, by which you obtain delicate fragrance by using a very cheap liquor. Such is what the French call "Court-Bouillon." To give this an English name, I will call it "flavoured water-broth," meaning that it is something more than water, and yet without meat. In effect, it is water to which you have added some vinegar, carrots, onions, parsley (whole), thyme, laurel, salt and pepper, and, after boiling the whole together, you use it—say to boil salmon. Insensibly the salmon will get a certain indefinite (the ignorant, without palate or nose, will say very indefinite) flavour, which will please the educated.

Ude, the great French *chef*, had special varieties of Court-Bouillon made with wine; but I do not think I shall add anything to the principle involved in the use of such a liquor by enlarging further on it. You must now go to the Cookery Book

TO STEW.

Soups.

Meat is composed of fibre, fat, gelatine, osmazone, and albumen. In making stock you will remove the scum (fat and albumen) as they rise to the surface. You will find more osmazone in old than in young animals, more in brown than in white meats. It is this element which makes your stock fragrant. Albumen is of the nature of white of eggs. You may dissolve it in cold or tepid water, but it will coagulate in water at boiling or a little under boiling-point (212° Fahr.). If you put meat in a stock-pot with the water boiling, you will form a crust or shell outside the meat, and prevent the gelatine and osmazone from dissolving. Result—a poor stock.

Bones are important in the stock-pot, as they contain, weight for weight, eight times the gelatine in meat. You should break them. Gelatine has no taste, and only in conjunction with osmazone affords a savoury stock.

Illustrating, then, by this verb the utensils named in their place—viz. stock-pot, pipkin, stewpan, &c.—I at once borrow from the recent Cantor lecture by Mr. Mattieu Williams, F.C.S., because nothing that I can say (with an exception that will be seen in a footnote) can better describe what the process of stewing is, and how deplorably deficient we are in it.

"The prevailing idea in England is that stewed meat only differs from boiled meat by being kept in the water for a longer time—that stewing is simply protracted boiling. I venture, nevertheless, to declare the total fallacy of this, and to assert that, so far as flesh food is concerned, boiling and stewing are diametrically opposite, as regards the special objects to be attained. In boiling a joint—say, a leg of mutton—the best efforts of the cook should be directed to retaining the juices within the meat, and allowing the smallest possible quantity to come out into the water. In stewing, the business is to get as much

as possible out of the meat, to separate the juices from the meat and convey them to the water. This is the case, whether the French practice of serving the liquid *potage*, or *bouillon* as a separate dish, and the stewed meat or *bouilli* as another, or the English and Irish fashion of serving the stewed meat in its own juices or gravy, as in the case of stewed steak, Irish stew, &c. The cruel murder that is commonly perpetrated upon good mutton chops, in preparing Irish stews, is very deplorable. The chops are put into a saucepan in water, and the water is *boiled* or '*simmered*,'* i.e. kept at 212°, whereby the albumen is at once coagulated, thus hindering the ready exosmosis of the juices. This is continued until both albumen and fibrin are so much hardened that they contract (as the white of egg does when used as a cement). The meat curls up curiously in consequence of this contraction, the albumen is made to resemble gutta-percha, and the fibrin to resemble cotton wool, before the extraction of the juices is completed.

"Not so with the frugal stew of the poor French peasant, who does more with one pound of meat, in the way of stewing, than the English cook with three or four. The little bit of meat, and the large supply of vegetables, are placed in a pot, and this in another vessel containing water —the *bain marie*. This stands on the embers of a poor little wood fire, and is left there till dinner-time, under conditions that render boiling impossible, and demand little or no further attention from the cook; consequently, the meat, when removed, has parted with its juices to the *potage*, but is not curled up by the contraction of the hardened albumen, nor reduced to stringy fibres. It is tender, eatable, and enjoyable, that is, when the proper supply of saline juices of the meat, *plus* the saline juices of the vegetables, have been taken into the system.

"Eaten alone, like our roast beef, it would be like the bone soup offered to the dogs by the academicians; but

* My idea of the word "simmer," as will have been seen, is that it represents the action of water at 158° to 165° on meat, and not that of water near boiling point.—S. B.

eaten with these juices, it is wholesome, and sufficiently savoury. Whether the *potage* and the meat should thus be separated, or whether they should be stewed together, as in an Irish stew, &c., is merely a matter of taste and custom; but that a stew should never be boiled, nor placed in a position on the fire where boiling is possible, should be regarded as a primary axiom in cooking where flesh meat is concerned.

In making soups or stewing a dish, our object is the reverse of that described under Roasting, Baking, or Boiling. We want no crust or shell around the inner fibrine and juices, but we desire to take these out and combine them with the more or less liquid surrounding them. In no case and for no purpose do we want them to be submitted to boiling heat, because we want no coagulation to take place. The better to act on it, beef should be cut up small.

The following is what Count Rumford said on the subject:—

"It is natural to suppose that many of the finer and more volatile parts of food (those which are best calculated to act on the organs of taste) must be carried off with the steam when the boiling is violent; but the fact does not rest on these reasonings. It is proved to a demonstration, not only by the agreeable fragrance of the steam, which rises from vessels in which meat is boiled, but also from the strong flavour and superior quality of soups, which are prepared by a long process over a very gentle fire.

"In many countries, where soups constitute the principal part of the food of the inhabitants, the process of cooking lasts from one mealtime to another, and is performed almost without either trouble or expense. As soon as the soup is served up, the ingredients for the next meal are put into the pot (which is never suffered to cool, and does not require scouring); and this pot—which is of cast-iron or earthenware—being well closed with its thick wooden cover, is placed by the side of the fire, where its contents are kept simmering for many hours."

To make a soup, whether it be thick or whether it be clear, you must first have stock, or broth. Mrs. Reeve thinks (and I quite agree) that where it be possible, a kitchen should have two stock-pots, one for making broth from fresh meat, the other in which carcases of roast chickens, game, rind of bacon, bones, &c., are thrown. Perhaps if you have the earthenware pot described among the utensils, it may be held to represent this second pot and be utilised for other than fresh meat. Copper is better than iron, and next to copper is earthenware.

You may make stock from beef, mutton, or veal, or any two of them, with chicken or the trimmings of chicken, if convenient. The fresher the meat the clearer the broth. The proportion of meat to water is about one pound to one quart. (*Reeve.*) The amount of bone to meat should not exceed one sixth.

You will let your meat simmer in the stock-pot for five hours, clearing off the scum as it rises, and you will introduce your vegetables when the skimming is finished.

Whatever vegetables you put in you will recollect that their purpose is to give a *general* flavour and not a predominant one. Nor is it intended that these vegetables are put in to be reproduced at the table. In cases where you have a vegetable, clear soup like Julienne, you cook your vegetables apart and add this broth.

All good cooks make their broth or stock the day before it is required, straining and putting it away carefully in an earthen pan in a cool place.

"To give a little colour," says Soyer, "as required for all clear soups, use a little brown gravy or browning, but never attempt to brown it by letting it colour at the bottom of the stewpan, for in that case you would destroy the greater part of the osmazone (the savouring element in meat)." The general consensus of opinion among the best cooks is that you should leave the pot uncovered. Towards the close, when the skimming is complete, you may put the lid partially, not wholly, on. Yet this view is not universal, and the very experienced lady superintendent of one of

the cooking school branches who has had lessons from good *chefs* writes thus to me:—"The *chef* at the Junior Carlton, also the *chef* at the Adelphi Hotel in Liverpool, and the late Monsieur Blanchet, of York, all keep the lids off their stock-pots; they say lid on makes soup cloudy and poor. I don't find it so. They say, with lid on the steam drops and so weakens the soup. I think it wastes a great deal of the flavour and certainly does not make it clearer. I also find that if the vegetables are put in only during the last hour-and-a-half, and the onion not skinned or fried, it makes a much better and fuller flavoured soup, as by long cooking the vegetables absorb a great deal of the flavour of the meat, and much of their own is certainly lost. Another thing I think cooks make a mistake in is, they say to boil greens a good colour you must leave the lid off. I find it does not make any difference; all they want is plenty of room and water, and certainly it helps to prevent any smell."

For all this, the profound respect I have for the late Monsieur Blanchet leads me to opine that nothing he did could be wrong, and *he kept the lid off.*

"The secret of making soup is to begin with cold water, to bring it slowly to the boiling-point, a mere ripple on the surface, to let it simmer gently and continuously for hours, never boiling up and never ceasing to simmer. On these three points—the gradual production of the heat, the moderation of the boiling (simmering) and keeping it up to the end—the flavour and clarification of the broth largely depend, and it is easy to manage this in an earthen vessel. But it is just as possible with an iron or copper stock-pot. It may not be so easy upon an open fire, but there is no difficulty whatever on the closed ranges which are now so common. There is another needless direction—soup should never be greasy. Every particle of fat should be removed. It is tedious to do so, however, by the ordinary process of skimming, and so we are sometimes advised to make the broth beforehand and to make a supply for two days. When the broth cools the fat will cake on the surface and then be

easily removed. The advice is good up to a certain point. It saves labour to make a good supply of broth at a time; it loses nothing in two days, even in hot weather, if kept in clean fresh vessels. But there is a simple mechanical contrivance to get rid of grease, which ought for ever henceforth to render the little eyes which appear on the surface of soup an impossibility. All the fat rises to the top of the stock-pot; if there is a tap at the bottom of it, the broth will flow out without a particle of grease. Common sense will tell the cook to beware of salt. It is well to put it in the stock-pot from the beginning, because it helps to make the scum rise; but what is barely enough for a full stock-pot may be a great deal too much when the liquid boils (simmers) down to half. The liquid flies off in steam, but the salt remains. The advantage of sugar is not so well known. It is as much for the saccharine matter which they contain as for anything else that onions, carrots, and turnips, are so necessary to the stock-pot. A little pinch of sugar at table is often a wonderful improvement to a tasteless soup. But a soup too sweet is sickly, and the cook must be very careful in applying it to the stock-pot. She must take into account also the sweetness of the caramel with which she will probably have to give the finishing touch of colour to the soup before sending it to table." (*Dallas.*)

"There are four different broths—two simple and two double—which are the foundations of nearly all the soups which can be imagined.

"1. Beef broth, or *bouillon;* 2. Double broth, or *consommé;* 3. Veal stock, or gravy (in French, *blonde de beau*—another double broth); and 4. Fowl broth, which is simple. There is a remarkable difference of opinion as to the quantity of cold water to be added to beef and beef-bone in order to make broth or *bouillon.* A pound of water is exactly a pint, and whereas some authorities (Liebig, Dubois, and Bernard, the latest) declare that a good broth requires equal quantities of solid and liquid, a pound of the one to a pint of the other—the most recent authority of all, and a very great one too (Jules Gouffé), recommends in one receipt

$2\frac{3}{4}$ pints, in another $3\frac{1}{5}$, in a third no less than 4 pints or pounds of water to the pound of beef. Here is an immense range, and between these extremes there is immense variety of opinion; the difference is incalculable between a broth made by adding a pint of water, and one made by adding four pints, to every pound of beef. And observe that the difference goes further than the simple broth or *bouillon;* it affects the character of the double or consumed broth which ensues. The first point of distinction between broth and double broth is simply in strength—the liquid used for the first being cold water, the liquid used for the second being the resultant broth of the first. But it can easily be understood that simple broth or *bouillon* made from equal quantities of beef and water is stronger and better than double broth or *consommé* which has been made from *bouillon* that has been diluted with four times its weight of water. All this shows the danger of being over-precise. A good deal must be left to the judgment of the cook, who has to take into account the result which he or she desires to obtain. A middle rule was laid down by the French chemist Parmentier, in the last century: let the water be double the meat—a quart for every pound. This is the ordinary practice of French kitchens. If the *bouillon* is wanted very light, redouble the water; if strong, reduce it. Another detail, and one not less important: the difference between *bouillon* and *consommé*, broth and double broth, is not merely in strength, it is also in character. The *bouillon* is a beef broth; the *consommé* is a beef broth which has been doubled with veal and fowl—the former to give it gelatine, the latter to give it flavour. But read the receipts for making up the stock-pot, or *pot-au-feu*, and producing its broth or *bouillon*. In all of them it is stated that while the beef is the essential consideration, we are free to add to it whatever else we have at command, veal, calves' feet, the remains of fowl, a trussed fowl if we want one for table, a leg of mutton, any trimmings of meat, pig-skin, a ham-bone, or even a whole ham if that should be in the way; and some of the great cooks

(like Dubois and Bernard) insist that the grand *bouillon* to be properly made must never be composed of beef alone: it must be composed of beef, veal, and fowl, the constituents of a *consommé*, in the proportion of 6 lbs. of beef to 2 of veal and 1 of fowl." (*Dallas.*)

VELVET-DOWN (*Velouté*).

(Gouffé's receipt slightly altered.) Take six pounds of veal and two hens with the fillets cut off. Put them into a stewpan with a quart of stock for every pound of veal and fowl combined. Boil it, skim it, add to it two sliced onions, two carrots, a faggot of sweet herbs, a little salt, mignonette, pepper, and sugar, and thicken all till the meat is cooked, when the stock should be strained through a napkin, and freed from fat. Mix, without browning, three-quarters of a pound of clarified butter with the same quantity of flour, add the stock to it; stir it on the fire till it boils, then simmer it on the stove corner for two hours to reduce it, get rid of all grease, and pass it through a taminy.

I have spoken of stock or broth made from the stock-pot, and preserved as the basis for other soups or sauces. I will now speak of a soup that may go direct from the stew-pan to the table. This is the *pot-au-feu*, which Gouffé calls *l'ame de la cuisine de ménage* (the soul of household cookery). Some one else said of it: "*c'est la soupe qui fait le soldat*;" and Henri IV. of France did not make himself unpopular when he gave expression to the wish that each of his subjects might have a hen available for his *pot-au-feu*. This shows that divers meats may be placed therein, and you are not restricted to beef, mutton, or veal. Here again I must impress on you that simmering of the gentlest character is necessary, and that a crust of albumen, the result of boiling, is fatal.

Put in, then, what meat you like, only of the very freshest kind, say two pounds to three quarts of water (others adopt one pound to the quart); let the water be cold; when you have taken the scum off, say when the meat is two-thirds

done, add your vegetables, carrots, leeks, turnips, celery, and the hearts of a cabbage or two. Turnips are dangerous in hot weather, as they make it turn sour sooner than if absent.

Set this *pot-au-feu* in your earthen or copper stock-pot, simmer for three or, if you like, five hours.

When ready for serving, the beef or mutton is taken out and garnished with the vegetables, pickled gherkins, or caper sauce, or, if veal, as a *fricandeau* with brown gravy, or, if a fowl, with rice, after being browned in the oven.

To serve the broth or soup, place slices of bread or crust in a soup tureen, on which a portion of the broth is poured through a colander. The bread is left to soak in this, and then the tureen is filled with the rest or a portion of it.

If you retain a portion or all for next day, you have another chance to remove the fat.

So important do I consider as a national question of economical utilisation of food, and a decent civilised way of presenting it on the table of persons of moderate means, that I pursue the subject of the *pot-au-feu*, in giving you the views of Carême, the great cook of bygone days. He says, "the stock-pot of the French artisan supplies his principal nourishment; and it is thus managed by his wife who, without the slightest knowledge of chemistry, conducts the process in a truly scientific manner. She first lays the meat into her earthen stock-pot, and pours cold water to it in the proportion of about two quarts to three pounds of the meat [this proportion has been disputed, and is more likely to have approached one pound to the quart]; she then places it by the side of the fire, where it becomes slowly hot; and as it does so, the heat enlarges the fibre of the meat, dissolves the gelatinous substances which it contains, allows the albumen (or the muscular part which produces the scum) to disengage itself, and rise to the surface, and the OSMAZONE (*which is the most savoury part of the meat*) to be diffused through the broth. Thus, from the simple circumstance of boiling (simmering) it in the gentlest manner, a relishing and nutritious soup will be obtained,

and a dish of tender and palatable meat; but *if the pot be placed over a quick fire* the *albumen* will coagulate, harden the meat, prevent the water from penetrating it, and the *osmazone* from disengaging itself; the result will be a broth without flavour or goodness, and a tough, dry bit of meat."

Liebig has not told us more than this, and it comprises the very quintessence of utilising meat in the most economical and tasty form.

Julienne soup may be taken as the type of herbal soups, and therefore it illustrates a principle. A soup *à la Jardinière* differs little from it, nor one *à la Macèdoine*, and in spring you may call it *à la Printanière;* with the onion and the cabbage, it becomes *à la Paysanne* (the peasant wife's soup), and with crusts of bread and the vegetables, somewhat less in number and cut more thickly, it becomes the *croûte-au-pot.*

Vegetable *purées*, on the other hand, find a type, say, in the very well-known *crecy* (carrot soup), where you rub the cooked carrots through a sieve, and add such broth, &c., as the cookery book may advise. Parsnips, onions, Jerusalem artichokes, &c., may be treated in the same way, and each *purée* has its predominant flavour.

Of meat or game *purées* hare soup is a type, and here again you make the animal or bird that gives the name present to you the special flavour.

Broth for the Sick.

Perfectly fresh meat, beef or chicken, cut up. Add 1⅓ lb. of distilled (pure soft) water, with 4 drops muriatic acid, and ⅓ drachm of common salt. Mix the whole well together, and after standing an hour strain through hair sieve, letting it pass without pressing or squeezing. The first portion will be cloudy, so pour again through the sieve, and so on until clear.

Upon residue in sieve pour ½ lb. distilled water.

Do not heat and keep well cold to avoid fermentation.

TO STEW.

(*Made Dishes and Sauces.*)

Time and the application of heat in a moderate form is the basis of all success in stews, hashes, ragoûts, Irish stew, curries, and made dishes, &c.; and let no one despise "made dishes," because the term has in some way obtained a disagreeable tincture of vulgarity. It has been well observed that the national dishes which constitute the fare of millions of men are nothing more or less than "made dishes;" witness the Irish stew, the Scotch brose and haggis, the *olla podrida* of Spain, the curry of India, and the pillaw of Persia, where princesses study the art of cookery to the great advantage of their guests.

The above list, with a certain pretension to accuracy, has something rhetorical about it. The Irish stew does not belong to Ireland, and if we could really say that it was a true English dish, we should not have to seek further for something answering to the *olla podrida* of Spain or the *pot-au-feu* of France to represent the greatest nation (boasting suppressed) that the world has ever seen. But Irish stew, good as it is, does not represent a permanent dish among us. Many of us might wish that it did, and that, as a matter of fact, enter into whatever inn or hostel we might, *that*, at any rate, as a toothsome dish should be ready for us. Were it permitted me to philosophise, nothing could be more curious than to reflect on this fact, that we have no such national dish.

If Henri IV. justly gained popular applause for the mere expression of a wish that every Frenchman should have a fowl for his *pot-au-feu*, how much better it would be if one could devise some national dish that might suit all tastes. I am far from thinking this an impossibility.

I do not think it should be quite an Irish stew. I think that fewer potatoes and some cabbage might enter into it. I am lost between my admiration of mutton and my leaning

in a national sense to beef, but I incline to the idea that beef, lean bacon, cabbage, onions, and a limited quantity of potatoes, with herbs and et ceteras thrown in, might form the base of an English stew which would have popularity.

Certain produce of the garden (celery) is so exceptionally better cooked than when, as with us is the rule, served raw that I depart from my rule of not giving special recipes, and will tell you how to utilise it for a tasty *plat*.

Celery.

(The dish is called celery *à l'Espagnole.*)

Select celery which is well grown, and not woolly inside; cut it into lengths of six inches, and blanch in boiling water. Line a stewpan with slices of bacon; place the celery on these, mix together four table-spoonsful of Espagnole (brown sauce) and the same quantity of broth. Simmer for three-quarters of an hour. Place the celery in the proper dish, remove the grease from the sauce and pour it round the celery.

Some people prefer celery served with a white sauce, such as you would supply with boiled chickens.

Cardoons, again, a vegetable little known in England, are excellent cooked. They are stewed first in a white sauce for three or four hours, and, after being strained, are warmed in brown sauce and served with croûtons of bread and marrow.

Aubergine has a stuffing of bread-crumbs, parsley, onions, and oil, and is excellent eating. This vegetable has become more common at Covent Garden than formerly.

Sauces.

The limits of this little Handbook do not permit me to treat at very great length of a department of cookery which, from its variety, presents to us an almost endless series of operations to be performed. When you have said that stock (see above), butter, flour, oil, parsley and all the herbs, cream and most condiments form the base of

sauces, we are as far as ever from giving you the information you may desire.

Let me, at any rate, begin by defining the distinction between butter melted (oiled butter) and melted butter (improperly so called). To the last the French give the name of white sauce, which is much more appropriate.

Oiled butter is the simplest (next to oil), as it is the cleanest, of all the sauces served. It is equally good for boiled fish or for asparagus. To make it, all you have to do is to warm your saucepan in warm water, to take care that it is clean and dry, to put in the quantity of fresh butter required, and let it melt on the hot plate or in the *bain marie.*

This oiled butter is the base of black butter, a sauce almost unknown in England, but invaluable to serve with skate. Here you allow it to become a rich brown, and then pass it through a strainer into another saucepan containing vinegar, salt, and pepper (three tablespoonsful of best vinegar to the ¼ lb. of butter); warm all together, and serve.

Melted butter is the basis for many English sauces. The simplest way to make it is to work some flour into the butter with a knife or spoon; then pour boiling water on them, stirring meanwhile; pour into saucepan, and just let it boil up. The great fault with English cooks is that they put too little butter and too much flour.

The white sauce of the English cooks is melted butter with milk instead of water. If it is wanted particularly rich, cream is used instead of milk. Take care of burning and boiling over. Of course you may vary this to advantage by flavouring with various ingredients and white stock.

Again, for sweet sauce for puddings, you may take melted butter, add a little sugar, the yolk of an egg, a glass of white wine, or a teaspoonful of brandy, lemon, cinnamon, etc., or colour it with currant jelly.

Another base for brown sauces is that termed in French *roux* (pronounced *roo*). It is flour browned in butter. "To make it, place in a stewpan ¼ lb. of butter, and heat it

gradually ; stir in four to five spoonsful of flour or potato starch with a wooden spoon ; let it cool a little, and then mix in your stock, taking great care that it mixes smoothly. Place it on a distant part of the hot plate, i.e. away from strong action of the fire, and let it simmer for one hour ; skim off the grease. Then put the stewpan on the warmer part of the hot-plate, that it may reduce or boil down. The sauce must not be too thick, or too thin, or too dark. Pass through a tamis, and use for mixing with flavour sauces. Remember that flour and water are not made savoury by butter alone, and that flour and water slightly cooked, and with a surface of butter, is not a sauce, but a nauseous substitute for sauce." (*Reeve.*)

It is convenient to keep flour ready browned in a bottle. Corn flour mixes more smoothly and is better than potatoe starch. A little amber gelatine previously soaked in cold water adds much to the richness of any sauce or gravy.

For sauces you require the measuring-glass mentioned under the head Weights and Measures, as by accurate proportion in blending flavours, combined with care in using fire, can you alone succeed.

Here you will find the faggot or bunch of fine herbs another essential base for refined sauces.

For particulars of what a faggot of herbs consists, I must refer you to the division "To Flavour."

In piquant sauces which are so varied you employ lemon-juice, vinegar, shallots, capers, &c.

If I were to give you the names of the most prominent known sauces, with their ingredients, you would realise how easy it may be to make two dishes in a very simple meal in discord one with the other ; as, for instance, if you were to treat your guest to grilled salmon with *sauce tartare*, and at the same repast inflict on him some dish with which Rémoulade sauce was served, he or she would think that you had a singular aptitude for the use of mustard flour ; or, supposing you gave him vermicelli soup, with grated Parmesan handed round, and afterwards turbot

with a Milanaise sauce (in which Parmesan appears), he might think that your views on the flavour of cheese were monotonous.

Hold, if possible, to this leading principle in devising a dinner, that the sauces that may form part in it must be diverse, and that no guest shall be able to recall a flavour already observed at the same repast.

You may with advantage follow the French in dividing your sauces into white and brown, and you will afterwards subdivide them. The French call their brown sauce *Espagnole*, because at one time Spanish tastes prevailed, and introduced the Montanche hams into their old brown sauce. Their white they call *Velouté*, and from these spring divers others.

These so-called white may be yellow (yolk of egg) or red (tomato); they are still white sauces in the language of the kitchen, being based on decoction—sometimes a very long decoction.

The difference between white and brown sauces is wholly a question of roasting (see effect of roasting coffee under the verb "To Roast"). Why this should be can be determined by oiling one piece of butter and roasting the other. The roasted butter will present to you a fragrance which has hitherto been hidden. I use the word roasting here in the sense that we roast coffee.

White sauces are the result of decoction, and no other heating process.

We should never have heard of sauce *à l'Espagnole* but for the existence of Spanish hams; and, so long as you introduce highly smoked ham into your brown sauce, you may call it Spanish, but not otherwise. Dallas says: "The introduction of the Spanish ham into the stock-pot for brown sauce is but one of many ways of getting the taste of the fire. Ham has been smoked, and a certain vapour of creosote and pyroligneous acid has been incorporated with it. The roast flavour which through the Spanish ham is supposed to improve a brown sauce is a modification of charred pinewood. Knowing this, we can rate at its

true worth the direction of the French cooks to put ham into all sauces and soups which are to be very good. The introduction of ham, or of anything smoked, in however faint a degree, into white sauce, is opposed to its character. It is quite possible that the creosote in the ham may be too feeble to do any harm: the question is, what good does it do?"

Some remarks by Dallas on Mirepoix sauce seem to me to involve a principle, and therefore I give them you in full. Like everything he wrote, they are replete with information, "Take two carrots, two onions, two shalots, two bay leaves, a sprig of thyme, a clove of garlic; mince them very small with half a pound of fat bacon, and half a pound of raw ham, and pass them in butter with pepper and salt. The Mirepoix is from this moment complete." [Mirepoix, I ought to add, is called from the Duc de Mirepoix, one of the Court of Louis XV.] "It will afterwards, according to need, be moistened and heated with wine, and then it will be a Mirepoix of white wine or of red—to be added to stock or sauce, to simmer in it and give it a flavour."

"*The published recipes say nothing about the mincing.* (Here is the principle referred to.) The direction is to simmer the Mirepoix for a couple of hours in order to extract the flavour, and then to strain it. On the other hand, it will be found that to mince the Mirepoix fine with a three-bladed mincing-knife will, in ten minutes, save a vast amount of time in cooking. It may require two hours to cook an onion or a carrot whole, and to extract all their flavour, but onions, carrots, and bay leaves, reduced to minute particles, yield all their excellence in a minute or two. In another point the foregoing receipt differs from the received authorities. They enjoin a quantity of veal and much more ham. But the veal is waste—there is little or no flavour in the infant beef, and its only use is to render the Mirepoix gelatinous. There is not the same objection to the ham; but it is not too much to say that, since Spanish notions on cookery became fashionable in France now nigh two hundred years ago, the great cooks of

Europe have become demented about ham, and have made all their sauces to run upon gammon."

Among the white sauces are comprised horse-radish mayonnaise, fennel, gooseberry, sorel, asparagus, mint, caper, mushroom, tomato, apple, onion, vegetable marrow, &c.

Mint Sauce.

Looking at the prevalence of lamb for one-fourth of the year and the just esteem in which it is held when cold, it is singular that the only sauce that goes with it should, as usually made, be unworthy of the name. I allude, of course, to that of mint. The restaurateur and the innkeeper would lead you, by their specimens of the article, to suppose that mint sauce was a boat full of indifferent vinegar into which a pinch of mint had been dropped to give it a name, and half a pinch of sugar, because some tradition had indicated the latter. Such a sauce represents the crimes of a portion of cooking humanity, ignorance and parsimony.

Mint sauce, when made, should be, as we say of rich cream, so thick that a spoon may almost stand in it, that is, you must not spare the mint but you may the vinegar, and your proportion of pounded white sugar should be so large that you produce a sub-acid flavour. You should never make your mint sauce till near the time of serving.

In the above remarks I endeavour to enforce a Principle, viz.:—that as extravagance is to be denounced, so parsimony is to be shunned, and that of all things in this world a sham sauce should never be concocted by the cook or served by the host.

Béchamel sauce is one of the divisions of white sauces. It is simply cream and velouté, or velvet down in equal parts. (*See* Soups.)

Mrs. Acton separated her gravies from her sauces, but as a gravy is a sauce, I do not see the necessity for the division; the more so as some preparations that Mrs. Acton calls gravies form the base of important sauces.

Sauce or Stewpan.

Clean and nice as enamelled pans are, the cook should remember that they retain the heat long, and you may have your sauce, which you only intended to bring to boiling point, continue to be acted on at a higher temperature than required after you have removed the pan away from the fire.

If I now leave this subject, I shall have to recur again to many points involved when I come to the verb "To Flavour."

TO BRAISE.

You may place your earthenware pot in a *bain marie*, and the oven instead of the hot plate is sometimes utilised. Pieces of meat with gristle can be made digestible by braising or stewing, if the process is carried out by a slow fire and for the proper length of time, that is, upwards of four hours, and if it is basted about every twenty minutes with the gravy which surrounds, but does not cover the meat.

To prevent the meat from burning, a round of buttered paper cut to the size of the stew-pan may be placed on the top of the meat, care being taken that it should not drop into the gravy. Of course it must be lifted each time the meat is basted. (*Reeve.*)

"Braising is a combination of stewing and baking. The meat, which is always nearly boned, is put into a copper stew-pan with broth and vegetables, and set upon embers or upon the corner of the stove to simmer very gently. Thus far it is the easiest-going stew that can be imagined. It is at the same time on its upper surface subjected to another process of heat. The lid is tightly closed upon it, sometimes with clay or dough, and is in a form to hold burning embers which ought to generate upon the surface of the stew a heat, that, if applied below and in contact with the metal bottom, might burn it. Below there is a

slow stew going on ; above, the meat is in a sort of miniature oven baking and browning. It is a favourite mode of cooking with the French, and is supposed to create unusual flavour, combining the advantages of roasting and boiling. Whether it does so is another question. Braised meat is no doubt an improvement upon boiled, but it never reaches the flavour of a roast. This, however, is a matter of opinion ; and French cooks often put paper over delicate meat which is to be braised—say a fowl or turkey—to make sure that the heat of the brasier above will not give it too much of a taste." (*Dallas.*)

Mrs. Acton says that no attempt should be made to braise a joint in any vessel that is not, say, nearly of its own size.

In consequence of charcoal being a common element in the French kitchen, braising is more easily effected there, and I do not dwell at very great length on the process, as I am convinced that it will never be a popular form of cooking with us.

TO BASTE.

"The *rationale* of basting," says Mr. Mattieu Williams, F.C.S., "appears to be that it assists in the sealing, and diminishes the evaporation of the juices of the meat, the chief difference between well-roasted and ill-roasted meat depending upon this. I define the roasting and grilling of meat as processes of cookery by means of which the meat is stewed in its own juices. The flavour depends on this : no water being used, these juices are not diluted—they are, on the contrary, more or less concentrated by evaporation ; but if this evaporation be carried too far, a drying-up occurs, and this desiccation, for reasons that will be explained presently, is accompanied with toughness and indigestibility, as well as sacrifice of flavour.

"The smaller the joint, the greater the risk of such desiccation."

TO BROWN AND CLARIFY.

Soyer says—"When in business and not so much time to devote to the kitchen, I used to make shift with a browning made thus, but I must add that I use a very few drops of it :—Put two ounces of powdered sugar into a middling-sized stew-pan, which place over a slow fire ; when beginning to melt, stir it round with a wooden spoon until getting quite black, then pour over it half a pint of cold water ; leave it to dissolve, and take a little for use when required. Burnt onions are used in France for this purpose."

The above is another form of caramel, which is made by browning pounded lump sugar in a stew-pan over the fire with a little broth, taking care it does not burn. It is used to colour sauces and gravies, and may be kept in a jar handy for use.

The salamander is the proper mode for browning, say, macaroni, etc. When you have not this utensil do it in front of a clear fire with any kind of tin reflector.

Clarifying is effected (1st) by skimming, (2nd) by white of egg or cold water, and sometimes by raw meat. For clarifying fat, see the observations under frying-pan (utensils).

TO FLAVOUR.

In defining the principles involved in the application of this verb, we may be said to quit science, and confine ourselves to the teachings of art, that will only produce happy results, as with a picture or piece of sculpture, when Technical Knowledge is combined with Taste.

In most, but not all cases, flavouring comes before cooking, and the technical knowledge is applied when the food is before you in a raw state, but even if you have succeeded in proportions you may afterwards spoil everything by

careless cooking. Flavour is given by Dame Nature to gratify our senses. It is one of the most legitimate pleasures in which we can indulge, always, be it well understood, in moderation. It is particularly valuable in the sick room, for by it you may tempt a patient who would otherwise refuse food. In this case, the sound old English phrase, "tickle the palate," is applicable.

Inasmuch as almost everything has a flavour of its own—I speak here of the additional flavour you impart to food by herbs, &c., or their extracts—I shall, with such exceptions only as may prove my rule, throw aside as illegitimate to my purpose manufactured sauces with which our shops team, and ask you to sieze on spices from the East or herbs from your garden, and employ your taste in utilising them.

One of the exceptions which will prove my rule will be curry powder, because you have not the materials fresh to hand by which you can make it for yourselves, and it is therefore that you shall employ a manufacture by others, if so be that you know where to purchase it.

The proper merit of a soup is the herbal flavour which it may possess. Not all soups certainly, because oyster soup, for instance, has a flavour due to oysters, and game soups the flavour of the game used. But your everyday soup, of which the liquid may be a *bouillon*, *consommé*, beef-tea, or broth (I use the words indifferently), resulting from the extraction of the juices of beef or mutton, will be flavoured most legitimately by the vegetables or herbs obtained from the garden.* Of extracts from herbs, or the like, which you will always keep by you, the most noted and the best is mushroom catsup. Of spices, black or red pepper, tabasco (a liquid extract from an American spice of a different flavour from, but allied to cayenne). By the combination of these with your vegetables or herbs will your taste be judged, and the art of the cook exemplified.

You must turn back to sauces to observe a great deal on

* A piece of bread on the point of your knife when peeling onions will prevent your eye-ducts being affected.

the details of flavouring, which might have come under this head, but which was perforce anticipated in dealing with them.

To succeed in flavouring you must not only be active and tasteful in the preparation of food; you must take care not to be passive in allowing defects to arise and flavour, once present, to escape by carelessness.

The following observations on this head are those to which I referred in the introduction, and are pregnant with common sense:—"One of the most conspicuous faults in English cookery is the presence of water. Sometimes the soup is little more than hot water. The boiled fish is sent up surrounded with hot water. The Irish stew has lost all savour by reason of water added to that which the vegetables in it have already yielded; and in the sending up of vegetables it is too apparent that the draining and evaporating processes have been omitted. Besides the objection that tepid water is not a sauce, there is the further objection that the water sent up has a disagreeable taste, and is unwholesome from the vegetable juices contained in it. A careful cook will press, squeeze, strain, drain, dry, or evaporate all vegetables that are cooked by boiling, and on the occasions when water is an ingredient in a dish, she will never exceed the quantity indicated. When broth is used to dilute a dish whilst it is cooking, only a small quantity is to be poured in at a time, and after that has been absorbed in stewing, a second dose may be administered. The practice of adding water to the gravy in the dish is to be severely reprehended. The gravy ought to be the pure juice from the roasted joints.

"Greasiness is a fault imputed to German cookery, not always without ground, but it is also to be met with in other countries. Grease, fat, butter, and cream, are important factors in most savoury dishes; butter and cream in sweet dishes also. Where then is this mistake when a dish is called greasy? In the case of soups, it is that the stock-pot has not been skimmed, and that the stock has not been allowed to cool till the fat cakes on the top, and can be removed. The same rule holds good with gravies and

sauces. When butter has to be mixed in with vegetables, if the butter is allowed to oil, the dish becomes greasy ; the mode of obviating this is to work flour in with the butter, and to allow the vegetables and butter and flour to be on the fire for a short time only, and not at all on a fierce fire. The overheating of fat is sure to result in oily, greasy dishes—this the cook can control. The soft, bad fat in meat, which is the result of the grazier's treatment of the animal, is not her fault. In frying, the defect of greasiness is the result either of the lard, butter, or oil, not being of the right temperature when the thing to be fried is put in it, or of the neglect of placing each thing after frying on a wire sieve, or on a paper on a dish before the fire, so that the fat which clings round may drain off on the sieve, or be absorbed by the paper placed under.

" There exists so great a difference of taste as to flavouring, that it is desirable for the lady of the house to explain to the cook what the standard of taste is to be on the following points :—

" Whether *much* pepper, curry powder, &c., are to be used in the dishes of which they are ingredients.

" Whether vinegar and lemon juice are to be used sparingly or lavishly.

" Whether spices and grocers' sauces are to be used at all.

" Whether sugar is to be put into puddings in such quantities as to satisfy those who like sweet dishes of the sweetest, or in moderate quantities, permitting addition to such as wish the dish sweeter.

" If the cook says she knows her business, the answer must be :—'You cannot know whether *we* prefer very highly seasoned dishes, or dishes of very delicate flavour ; and it is no imputation of want of skill, when I explain that we like clear soup without wine, and very little pepper ; that creams are, in our view, best without gelatine ; or that an apple tart, in which there were cloves, would be sent untouched from our table."

In France, *the standard of taste* is uniform, or nearly so, and the tradition of the kitchen may be trusted even where there is no *chef* to direct.

In England, tastes differ; the tradition prefers flavours from the *grocer* to flavours from the *garden*, and the cook's palate can rarely be trusted.

Whilst nothing can be truer than the remark that sound healthy life, whether in the animal or vegetable kingdom, is quite inconsistent with the habitual use of a highly stimulating diet, it is at the same time necessary to study the peculiarities of those palates and digestions which have to be kept in healthy order, to consult idiosyncracies, and to humour whims as far as is possible. There is neither sense nor saving in using that against which the stomach is set.

A remark by Dr. Brunton deserves to be quoted on this point:—

"Savoury food causes the digestive juices to be freely secreted; well cooked and palatable food is therefore more digestible than unpalatable, and if the food lack savour, a desire naturally arises to supply it by condiments, not always well selected or wholesome." (*Reeve.*)

Condiments.

Among the simplest condiments which play so large a part in cookery may be mentioned salt, sugar, vinegar, or its equivalent, lemon or lime juice, and mustard. These are the poor man's aids to the most ordinary forms of cooking or the preparation of food. It would be a happy thing if science could furnish us with oil at such a moderate price that we might include it among the poor man's condiments.

Certainly Nature does not, for even the richest household cannot purchase pure olive oil, and its adulteration more often takes the form of 95 per cent. of other oil. He who gets a so-called salad-oil with 40 per cent. of pure olive oil may consider himself lucky.

You will remember the many uses of sugar in the matter of flavouring. It renders watery and insipid vegetables,*

* About an ounce of white sugar to two gallons of water is not without its advantage, particularly in winter, when vegetables have less saccharine matter.

such as peas, spinach, endive, more digestible, and broths and gruels, the insipidity of which is due to their starch, become more agreeable. It tempers the acidity of certain fruits, and when employed in such small quantities as to be unsuspected, it softens as well as heightens the flavour of many *savoury sauces and ragoûts.* So employed, it forms a connecting and harmonising link between the sharpness of salt and the pungency of spice. Sugar is suitable to every temperament, climate, sex, and age. It is almost the only seasoning allowable to persons whose system is suffering from irritation, such as convalescents recovering from inflammation of the stomach, bowels, lungs, &c. (*Delamere.*)

Salt (chloride of sodium) I need not dwell on.

Vinegar is properly obtained by the acetic fermentation of wine, but it is very difficult to obtain. Ordinary English vinegar is, so far as the kitchen is concerned, a chemical monstrosity. Try and buy French vinegar from a respectable Italian warehouseman. Herbal vinegars require careful treatment and must not be boiled.

Wherever mustard is prescribed in a recipe for a sauce mustard flour is meant, and not mustard that you have made for the cruet-stand.

With reference to the very strong flavour of garlic, the "prince of the onion tribe" as I have called it elsewhere, remember that you may often get all the flavour you require, say a mere suspicion, by rubbing a knife or a dish with it.

In any case, for social reasons connected with its peculiar smell, it must be used very carefully, but there are cases in invalid cookery where it becomes indispensable.

"Onions, cloves, rocambole, shalots, and leeks, belong to the same natural family as garlic, and possess the same properties, only in a less degree. Rocambole comes nearest to it." (*Delamere.*)

Pepper, ginger, allspice, cloves, nutmeg, cinnamon, capsicum or cayenne pepper, mustard, and horse-radish, all come under the head of condiments for seasoning.

"Their importance lies in this, that as all animals are

nourished, not so much by the quantities of nutriment contained in their food, as by their power of digesting it, so whatever assists digestion, at the same time increases digestion. To maintain health and favour growth, the *two* conditions must be present—the food must contain sufficient aliment, and the stomach must have the power of appropriating that aliment. Food, however nourishing, which is not digested, renders no service to health and strength; the eater might as well have eaten substances absolutely innutritious." (*Delamere.*)

Under the verb "To Simmer," you will find some remarks on Court-Bouillon or flavoured water-broth, a very delicate form of conveying flavour to fish.

As already remarked, I have carefully excluded from these principles a recognition of the manufactured sauces sold by the grocer, for the simple reason that their constituents are unknown to me. How well you may do without them, and yet know what your flavouring shall be, if you will only take some trouble, is well exemplified in the recipe given in Professor Bradley's 'The Country Housewife,' from which I have already quoted.

A Dry Travelling Powder for Sauce, or Pocket Sauce, from Mynheer Vanderport of Antwerp.

"Take pickled mango, and let it dry three or four days in the room; then reduce it to powder by means of a grater. Take of this powder six ounces, to which add three ounces of mushrooms, dried in a gentle oven and reduced to powder by beating in a mortar; add to this a dram of mace powdered, half as much cloves powdered, or in their room, a large nutmeg grated, and a dram of black pepper, beat fine. Mix these ingredients well together, and sift them through an open hair-sieve, and half a teaspoonful, or less, of the powder will relish any sauce you have a mind to make, though it be a quart or more, putting it into the sauce when it is warm. To this one may add about nine grains of sweet basil, dried and powdered."

I do not think this recipe is less valuable because it is old, and certainly the various housewives throughout the country who supplied the learned Professor of Botany with their several recipes, seem to have had a far higher ideal before them in the matter of flavour than obtains among us at the present day. The fact is, they believed in the virtues of herbs, lemon-peel, &c., and did not depend on the grocer to furnish them with a ready-made conglomeration of spices to save themselves trouble.

On the other hand, there are plenty of what may be called store sauces, of which you know the ingredients that may safely be taken under your consideration and valued for their individual flavour.

Of such are mushroom and walnut catsup, Tarragon vinegar, eschalot or garlic vinegar, eschalot wine, anchovy sauce, mushroom powder and powder of savoury herbs, or of the faggot of herbs already mentioned. Wherever a herb is powerful, and you can present it in a liquid form, there you are secure to apportion the flavour with the greater delicacy.

A bunch of herbs (*bouquet garni*) represents that in the kitchen which in the flower-garden we should call a nosegay, but for bunch the word faggot is more in use. There are various faggots, and Dallas, in his invaluable work ('Kettner's Book of the Table'), has made the following enumeration of them :—

(1) *Faggot of Parsley.*—This is a little bunch of parsley tied up with cibols or spring onions. It is in French called a bouquet.

(2) *Faggot of Sweet Herbs.*—What the French call a *bouquet garni.* This used to be described as a faggot of parsley with the addition of a bay-leaf and a sprig of thyme. As in practice, however, when this faggot is used, there are onions or shalots besides, the cibols or spring onions of the parsley faggot come to be of small account. It is better, therefore, to leave out the cibols, and to describe it as made up of parsley, bayleaf, and thyme.

(3) *Faggot of Ravigote.*—Tarragon, chervil, burnet, and

chives. Sometimes there is parsley, but it is quite unnecessary beside the tarragon and the chervil, and it is a good illustration of the indiscriminate fashion in which cooks throw in one good thing after another. It is the old story of the artist who could paint a cypress, and therefore put a cypress into all his pictures, no matter what the subject. Parsley is a good thing, and therefore cooks will strew it everywhere.

(4) *Faggot of Duxelles.*—Dubois and Bernard have called this Fine Herbs, and Gouffé, without adopting the name, has given his opinion in favour of it. There are reasons why we should still keep to the old French name of Duxelles. Ever since Beauvilliers laid down the law, the faggot of Duxelles has consisted of equal weights of mushrooms, parsley, and shalots, minced finely together, and fried for five minutes with rasped bacon, pepper, and salt. In later times, those who can get it add an equal weight of truffles. It is a question, however, whether the quantity of parsley and of shalots is not excessive. In the mind of the inventor, the mushrooms were intended to predominate. But if to half a pound of mushrooms you put half a pound of parsley, and on the top of that half a pound of shalots, it scarcely stands to reason that the mushrooms should have much the best of it.

(5) *Faggot of Mirepoix.*—Two carrots, two onions, two shalots, two bayleaves, a sprig of thyme, a clove of garlic, half a pound of fat bacon, and possibly half a pound of ham. Chop these finely, and pass them in butter for five minutes with pepper and salt. See under Sauces "Mirepoix."

(6) *Faggot of Potherbs.*—The following receipt is nearly identical with what the French cooks call Poele, only that it wants veal and ham. "Take two carrots, two onions, two cloves, and a faggot of sweet-herbs ; mince all finely with half a pound of beef fat, and melt it on a slow fire, with a little broth and salt, and the juice of at least one lemon. It will be observed that the chief difference between this and the Mirepoix is that it has less of the onion tribe in it, that it has a quantity of lemon-juice, and that fresh fat is

substituted for the smoky bacon fat. If this faggot be put into a saucepan with no broth, but plenty of water (say three quarts), together with some flour, and if it be then boiled for half an hour and strained, the resulting liquor is what French cooks call *blanc.*" (*Dallas.*)

These, you will observe, involve distinct principles in the higher branches of cooking, and until you have seized the point in variety and distinction which these several faggots offer, you cannot hope to achieve success in flavouring soups, sauces, made dishes, stews, &c.

As much may be said on the point of various flavours connected with sweet dishes, which require extreme delicacy, but it is impossible for me to enlarge upon them.

Care must be taken with all sauces in which eggs are used that the egg does not curdle, which it must do if cooked over a fierce fire.

"When you are directed to use the pulp of a lemon it means that you are to pick out the pips in the first instance."

> "Nec sibi Coenarum quivis temerè arroget artem
> Non prius exactâ tenui ratione saporum."
>
> Hor. Sat. lib. II; Sat. 4.

"Let no rash novice assume that he can compose a *menu* till he has worked out the delicate theory of flavours."

or

> "Let none presume to claim offhand
> The dinner giving Art : in reason
> He first of all must understand
> The *when*, the *why*, the *how* to season."

TO SERVE.

The duties of a cook are not completed until the dish prepared has been served—that is, either placed directly on the table personally, or given into another hand for immediate placing before the person or persons who are to partake of it.

For good service you require attention to—

1. Cleanliness of the most exacting character ;

2. Heat for dish, cover, and platter where food is hot; cold, and not merely lukewarm, plates or dishes where the food is cold.

The taste which you may display in the form of your food, or the decoration which may be thought agreeable to apply to it, are quite beside "Principles." They are adjuncts, and most useful adjuncts, where labour, which means time and money, is at your disposal; but they are not necessaries, and I have endeavoured to insist only here on such principles as are equally demanded in the cottage as in the palace.

Not that in the cottage the cook should not try to do the best in serving things tastefully, as delicate appetites are much affected by it.

In serving potatoes or rice, covers should never be put on. At most a napkin or doyly may be put over to preserve them from a cold current of air. This will absorb the steam and save the food from moisture, which is repugnant to the dish.

"The order in which articles of food are eaten is also not without importance. The keeping back of the most stimulant dish until the close of a meal is an assistance rendered to digestion, which is usually retarded by the reception of sweet or insipid substances. Such may be partaken of with greater advantage when the stomach still is empty." (*Delamere.*)

To this I may add that ices are the falsest and wrongest things to be produced at the end of a repast.

It is as well also that the cook should impress on the serving man or maid what sauces attend certain fish or meats, as melted butter with fish, mint sauce with lamb, &c.

Strictly speaking, for the purposes of this Handbook, it may be said that the cook's responsibility ends here; and it certainly is not his or her fault if English fashions have brought about, in contradistinction to the simpler methods in France, an accumulation of different foods on the same plate, which are a source of anxiety to the serving man or maid. If in the dining-room we were satisfied with a dish

such as the cook may send up, we should not have one guest expecting ketchup, another anchovy sauce, and, almost all, potatoes to every dish. Even with this people are not contented, but will look for other vegetables as well, as if vegetables were produced by Nature for no other purpose than to be accumulated on a plate by the side of meat. On this point I may well quote what I said in a previous essay, viz., "that the English will not understand that a vegetable should be served, if cooked, as a *plat* to be criticised gastronomically by itself, and not as a concomitant or accident, if we may so express it, to more solid food."

And as I have spoken of English fashions in the dining-room, I cannot but say that if it were the rule that red and white wine, with an accompanying carafe of water, were placed within reach of each guest, and that each were expected to help themselves, a great labour would be taken off the hands of those who serve.

In writing this I feel that I am going beyond due bounds, because this Handbook is not necessarily written for persons who have red or white wines at their table; but even be it wholesome table beer, I insist that it should be placed within reach of each guest, and not left for the maidservant to pour out. It should be our duty and pleasure to lighten her services in every possible way.

Under this head "To Serve" I ought to include the words "service" or "course," and explain the principles which should govern the rendering of them, and I trust that it will not be thought foreign to the purpose of this Handbook. Yet I fear that any one capable and disposed to write on this subject can hardly do otherwise than assume a somewhat dogmatic tone, that may be ungrateful to an English public.

As a rule it may be said that what a "course" should be is little understood with us, as Dr. Mitchell says in the letter which appears in my work (p. 51) named in the introduction:—

"Those who are familiar with the gastronomical art and

its history, know of how much more subtle a nature is the 'course' (than as understood in England) in its true meaning of the French *service*, namely, that it is an arbitrary arrangement in the service of the dishes of a repast, with the object of setting it out in three distinct acts —three tables (*mensæ*)—each in a manner complete, yet differing in character and kind. The 'course' is an inheritance from classical times, come to us through Italy and France. It has never been understood or practised outside of western Roman civilisation. It has on that account all the more charm for those who are able to appreciate it. To such it is consequently painful to hear from the mouths of almost all in this country the term (containing as it does so much of refinement) applied to such vulgar set-outs as your 'two soups,' 'two fishes,' &c."

As this kind of criticism may be puzzling, I will give you an example of a dinner of two "courses," arranged by the great Caréme, using as far as possible English terms.

MENU FOR A DINNER FOR FROM 6 TO 9 PERSONS.

Soup	Semolina.
I.	
Large piece	Beef à la Maréchale.
Two Entrées	Partridges.
	Hashed Chicken.
II.	
One dish of Fried or Roast . .	Whiting in the English way.
Two Entremets	Spinach with White Sauce.
	Madeira Jelly.
Extra	Apricot Pudding.

You will say that the fish here comes in at an odd period. The answer is that, after taking off the edge of the appetite with a light soup, the heavier foods should be attacked, and that a light food, like whiting, &c., may well come in afterwards.

More than this I will not say, because fashion and habits

are not to be changed in a day. I only want to illustrate what Dr. Mitchell means when he says that we know not what a "course" or *service* is.

PASTE AND PASTRY.

The principles involved in making these include what is subject to action of the oven or the frying-pan, and what (puddings) to the action of water.

When I have given you some very leading necessities I shall have written all that is useful to write.

Art, which cannot be described by the pen, comes in here, and such is its character that you may say, as you speak of ancient Italian art in painting or the modern French school, that this of making pastry belongs to a nation or a tribe.

The Engadine and other Swiss-Italian valleys send out proficients in it. Italy itself is not wanting, and possibly France may have the breed, but the highest qualities of the *pâtissier* are rarer in England, although Scotland is great in cakes, and, as far as I know, they do not exist in Russia or Sweden, but Germany and Austria are great in the matter of bread.

If I have insisted on cleanliness elsewhere, I must insist on it as much or more here. Your flour must be dry, your butter must have no salt or butter-milk in it, your lard must be sweet, your suet finely chopped and free from skin, and you should dredge it with flour as you chop it. You may use clarified dripping sparingly, and you may get a shorter crust by adding a little moist sugar, the yolk of an egg, or a little lemon-juice. N.B.—Your hands should be clean as if you were about to prepare a salad without the intervention of knife or spoon. (*See* Salads.)

Never use your pastry-board for any other process.

You cannot make pastry if you have not delicacy of touch.

Soyer very justly says, "The variety of pastes is to pastry

what first stocks are to soups and sauces; . . . to succeed you must be particular in your proportions, and very careful in the mixing; for, although there is nothing more simple if pains be taken, so will the least neglect produce a failure; nor is it only with the making of the paste that pains must be taken, but likewise with the baking, for, as paste badly made would not improve with baking, neither will paste, however well made, be good if badly baked; should the oven be too hot, the paste will become set, and burn before it is done; and again, if too cold, it will give the paste a dull heavy appearance. . . . For every description of pastry made from puff paste, try if the oven is hot by placing your hand about half-way in, and hold it there about a quarter of a minute; if you can hold it there that time without inconvenience, it would not be hot enough; but, if you cannot judge of the heat, the safest method would be, try a piece of paste previous to baking the whole."

I may interpose here that the thermometer should be a better tell-tale, as the sensitiveness of the hand must vary with each person.

To make puff-paste, from which Soyer says upwards of a hundred different kinds of cakes may be made, I give you his process:—

"Put one pound of flour upon your pastry-slab; make a hole in the centre, in which put the yolk of one egg and the juice of a lemon, with a pinch of salt; mix it with cold water (iced in summer, if convenient) into a softish flexible paste with the right hand, dry it off a little with flour until you have well cleared the paste from the slab, but do not work it more than you can possibly help; let it remain two minutes upon the slab, then have a pound of fresh butter from which you have squeezed all the butter-milk in a cloth, bringing it to the same consistency as the paste, upon which place it; press it out with the hand, then fold over the edges of the paste so as to hide the butter, and roll it with the rolling-pin to the thickness of a quarter of an inch, thus making it about two feet in length; fold over

one third, over which again pass the rolling-pin ; then fold over the other third, thus forming a square ; place it with the ends top and bottom before you, shaking a little flour both under and over, and repeat the rolls and turns twice again as before ; flour a baking-sheet, upon which place it, upon ice or in some cool place (but in summer it would be impossible to make this paste well without ice), for half an hour ; then roll twice more, turning it as before ; place again upon the ice (or cool slab) a quarter of an hour, give it two more rolls, making seven in all, and it is ready for use when required, rolling it whatever thickness (according to what you intend making) directed by the special recipe you are going to employ."

As the above is a somewhat difficult and extravagant formula, I would advise those of moderate means to refer to a simple cookery book for other modifications of it.

Pastry or crust for puddings that are to be boiled must be made with simpler ingredients—flour, suet, and water chiefly, the quality depending on the greater proportion of suet. You may use butter in place of suet, and you may use clarified dripping for kitchen puddings, but suet is the main principle in crusts that have to be boiled.

If you boil in a mould, line it with butter (thin), and without salt in it.

If you boil in a cloth, damp it and coat with flour, or even butter it.

According to the character of your pudding, tie up tightly or loosely. Bread and plum puddings require room to swell ; batter, on the other hand, does not.

Put away your pudding-cloths *clean and dry.*

Take care to have them of various sizes.

When you have to use eggs in pastry, look carefully to their freshness.

Batter must be mixed by degrees, so as to ensure smoothness.

Mix your dry ingredients before they are wanted. The liquid you can add at the last moment.

Place a plate reversed at the bottom of the saucepan in

which you boil your pudding, whether this is in a mould or a cloth. The cookery books will tell you to keep your pudding well covered with water when in a mould. I differ from the cookery books, and would never allow the water to be above the top of the mould. When you have tried my method, you will perceive that steam has something to do with cooking, and that a cook careless about her cloth and the buttering thereof, should leave no chance to allow water to enter the pudding and weaken its contents.

Take care that your water boils, and does not cease, and add hot water as it gets reduced.

If you dip the boiled pudding (in cloth) into cold water the moment you take it out, it will not stick to the cloth. If the cloth has been well buttered there is no need for this.

Milk is a main ingredient in a large variety of puddings. Some of these you will boil or simmer and then bake. Here you cannot be too careful about burning, and the double saucepan will become useful.

The origin of the word "pie" has been a matter of controversy. It appears to have existed before *pastie* or *pastye*, and Dallas thinks it must have been derived from *pied* and *pain*. The English form and spelling of *pied* is *pie*, as in *cap-à-pie*. To this day, on the top of a pigeon-pie, appear the feet, which would seem to be an allusion to the name, whilst *pain* might seem to have denoted the crust. Todd Johnson's Dictionary asserts that in some parts of England an apple-pie is called an apple-foot.

KICKSHAWS, OR *HORS D'ŒUVRE.*

Without exact knowledge in this particular, I assume that kickshaws is a good Saxon term for the various articles of which I am about to speak. *Hors d'œuvre* have been defined as a term for any dish which people can dispense with without injuriously affecting the service of a dinner. Taken as a whole and served simultaneously, they are

represented by the word *zakouska* in Russia, *smörgåsbord* in Sweden, and by *antipasto* in Italy, meaning a collection of prepared but, with some exceptions, little cooked dishes that are placed on the dinner or, by preference, a side-table for consumption before dinner.

Before dinner, or the principal meal, I say, in the case of Russia and Sweden, but in France as much at the breakfast as at the dinner-table.

I rather think that the *raison d'être* of this ante-prandial food differs according to climate. In the south of Europe I should divine that it was established as a whet to the appetite; whereas in the North it has grown up as a useful stay for the appetite of the guest who arrives sharp set and hungry from the keen northern air, and has this placed before him by the ever-hospitable hosts of northern climes. I recollect myself that, after a fifteen-mile drive across the frozen gulf at St. Petersburg, we were very glad, on arriving at our destination, to spend the half hour necessary to get dinner prepared in a very large consumption of this *zakouska*.

With us this *anti-pasto* has never obtained, and in dwelling on its constituents I may be accused of making this simple Handbook a passport for the *gourmet*; but such is not my intention. Kickshaws are a recognised article of food, and the preparation, if not the cooking, of them comes within some of the principles, the compilation of which is the *raison d'être* of this Handbook.

What are kickshaws or *hors d'œuvre?* Here I have to depart from the principle I laid down in my remarks on sauces, and include manufactured articles. But my reason may be made clear. In dealing with manufactured sauces I had to deal with unknown proportions of various condiments. In dealing with manufactured kickshaws or *hors d'œuvre*, I shall but rarely have to refer to compositions other than those recognised for their ingredients or as simple foods.

Of such are smoked salmon, cooked (or uncooked) haddock, herrings, sardines, tunny, anchovies, pickled fish,

including cockles and mussels, potted shrimps, lobster, &c., brawn, gelatine, caviare, *pâté de foie gras*, *terrines de Toulouse* or *de Perigord*, but not, as some have included, venison pasty, goose-pie, or the like.

Also are there forms of sausage, such as the Bologna and the Arles, which are eaten without further preparation.

I am uncertain under what class to rank the marrow-bone or rather the contents of it, with toast, but assuredly it can scarcely be treated as a *hors d'œuvre*.

Then we have, or perhaps I should have given them the preference, radishes, spring onions, watercress, olives, raw celery, cucumber, red cabbage, gherkins, walnuts, mangos, &c.

Of these last few are prepared, and you may think that I leave you in face with certain manufactured articles which you buy and others which you are not to be at the trouble of preparing. But this would be an error. The cook's dexterity will be shown in assorting and preparing these divers forms of food in such a manner as to make the *zakouska* or *anti-pasto* a delicate preparation for the meal to follow.

Here are a few original forms which you may serve on fancy paper.

1. Norwegian anchovies on thin strips of brown bread and butter, with radishes between, and a bunch of watercress in the centre.

2. Dried salmon in thin strips on brown bread and butter, with garden cress cut short and sprinkled.

3. Sardines scraped, boned and cut into strips, laid crossways on thin rounds of bread and butter cut from a French roll, with a caper in each square, and a sprinkling of chili vinegar.

4. Sardines scraped, boned and halved, laid on brown bread and butter, with the yolk and white of a hard boiled egg chopped fine, and chopped parsley, little heaps between. A few drops of tarragon vinegar on the sardines.

5. Slices of a large lemon cut thin, and a well soaked anchovy curled on each, with four or five capers in the middle, and three-cornered bits of bread and butter between; the whole garnished with parsley.

6. Grated ham and tongue on bread and butter, with spring onions chopped fine between.

7. Prawns skinned and laid on brown bread and butter, with small lettuce-leaves between, both as garnish and to eat, and a few drops of tarragon vinegar.

8. Caviare on slices of brown bread and butter, or French roll or Vienna bread garnished with watercress.

9. Any potted meats or Bologna or Arles sausage on strips of brown bread and butter, to be treated with one drop of Tabasco sauce for each strip, and finely chopped spring onions.

SALADS.

In that quaint book, by John Evelyn ('Acetaria,' 1706), he opens by the remarks addressed by Lord Somers, P.R.S.: "I expect some will wonder what my Meaning is to usher in a *Trifle* with so much magnificence, and end at last in a fine *Receipt* for the *Dressing* of a Sallet with an Handful of *Pot-Herbs!* But yet this *Subject*, as low and despicable as it appears, challenges a part of *Natural History;* and the *Greatest Princes* have thought it no Disgrace, not only to make it their *Diversion*, but their *Care* . . . The Ancient and best Magistrates of *Rome* allow'd but the *Ninth* Day for the *City and Publick Business;* the rest for the *Country* and the *Sallet Garden.*"

But let me get on to his views about the plants. "Sallets in general consist of certain *Esculent* Plants and Herbs, improv'd by Culture, Industry, and Art of the *Gard'ner;* or, as others say, they are a composition of *Edule* Plants and Roots of several kinds, to be eaten *Raw* or *Green*, *Blanch'd* or *Candied;* simple, and *per se*, or intermingl'd with others according to the Season. The Boil'd, Bak'd, Pickl'd, or otherwise disguis'd, variously accommodated by the skilful cooks, to render them grateful to the more feminine Palat, or Herbs rather for the Pot, &c., challenge not the name of *Sallet* so properly here, tho' sometimes mention'd; and therefore, those who *Criticise* not so nicely

upon the Word seem to distinguish the *Olera* (which were never eaten *Raw*) from *Acetaria*, which were never boil'd; and so they derive the Etymology of *Olus* from *Olla*, *the Pot* . . . as it concerns the business in hand, we are by Sallet to understand a particular Composition of certain *Crude* and fresh Herbs, such as usually are, or may be safely eaten with some *Acetous* Juice, Oyl, Salt, &c., to give them a grateful Gust and *Vehicle* . . ." I suppose Evelyn would have classed Celery among the Olera, although he looks on Artichokes and Cardons as possible to eat without the intervention of the cook. Of Basil he says it is to be sparingly used; of Baulm that it strengthens the Memory, and chases away Melancholy, of Beet that it is laxative, of Blite (English mercury), that it is insipid, of Borrage, that it is purifying. I have not space to detail his curious analysis of all the herbs, but what he says of cucumber may interest a good many. "Cucumber, tho' very cold and moist, the most approved *Sallet*, or in Composition, of all the *vinaigrets*, to sharpen the Appetite, and cool the Liver, &c., if rightly prepared; that is by rectifying the vulgar Mistake of altogether extracting the Juice, in which it should rather be soak'd; nor ought it to be over *Oyl'd*, too much abating of its grateful *Acidity*, and *palling* the Taste from a contrariety of Particles; let them, therefore, be pared and cut in thin slices, with a *Clove* or two, of *Onion* to correct the Crudity, Macerated in the Juice, often turned and moderately drain'd. Others prepare them by shaking the Slices between two Dishes, and dress them with very little *Oyl*, well beaten, and mingled with the Juice of *Limon*, *Orange*, or *Vinegar*, *Salt* and *Pepper*. Some again (and indeed the most approved) eat them as soon as they are cut, retaining their Liquor, which being exhausted (by the former Method), have nothing remaining in them to help the concoction. Of old they boil'd the *Cucumber*, and paring off the Rind eat them with *Oyl*, *Vinegar* and *Honey*; *Sugar* not being so well known. Lastly, the *Pulp* in Broth is greatly refreshing, and may be mingled in most *Sallets*, without the least damage

contrary to the common Opinion, it not being long, since *Cucumber*, however dressed, was thought fit to be thrown away, being accounted little better than Poyson. *Tabernier* tells us that in the *Levant*, if a child cry for something to Eat, they give it a raw *Cucumber* instead of *Bread*. The young ones may be boil'd in White Wine. The smallest sort (known by the name of *Gerckens*) muriated with the Seeds of *Dill*, and the *Mango* pickle are for the Winter."

Of garlick (Allium), John Evelyn says in his quaint way, "dry towards excess; and though both by *Spaniards* and *Italians* and the more Southern People, familiarly eaten with almost everything, and esteemed of singular Vertue, and thought a Charm against all Infection and Poyson, we yet think it more proper for our Northern Rustics. . . . We absolutely forbid it entrance into our salletting by reason of its intolerable Rankness, and which made it so detested of old; that the eating of it was (as we read) part of the Punishment for such as had committed the horrid'st crimes. To be sure 'tis not for Ladies Palats, nor those who court them, farther than to permit a light touch on the dish, with a *Clove* thereof, much better supplied by the gentler *Roccombo*. Note, that in *Spain* they sometimes eat it boiled, which taming its fierceness, turns it into nourishment, or rather *Medicine*.

"Leeks and *Cibbols*, *Porrum*, hot and of vertue Prolifick; since *Latona*, the Mother of *Apollo*, long'd after them: the *Welsh* who eat them much are observ'd to be very fruitful. They are also friendly to the Lungs and Stomach, being sod in milk; a few therefore of the slender and green summeties, a little shred, do not amiss in composition.

"Onion, *Cefa*, *Porrum*; the best are such as are brought us out of *Spain*, whence they of *St. Omer's* had them, and some that have weigh'd eight pounds. Choose therefore the large, round, white and thin-skinn'd. Being eaten crude and alone with *Oyl*, *Vinegar* and *Pepper*, we own them in *Sallet*, not so hot as *Garlick*, nor at all so rank: Boil'd they give a kindly relish; raise appetite, corroborate the Stomach, cut Phlegm, and profit the *Asthmatical*: But

amusing way, recounts that, failing everything, he at last got a landlord to lend him a punch-bowl, in which to make a salad.

As in the case of sauces, the rules laid down for the compilation of this Handbook preclude me from giving you general recipes. I am obliged to stick to principles, and I will endeavour to explain to you the general principles which underlie the preparation of a salad.

These are—1, that something of a fatty or oily nature should be applied; 2, that you should have a condiment of salt, sugar, pepper (red or black); and that, 3, you should apply an acid (vinegar or lemon) to temper and amalgamate these elements.

Before I apply these elements to the vegetable that may be before you, I will ask you to first wash your hands, as if you were about to handle pastry for a delicate bride-cake, or as if, were such a thing possible, the bride might be prepared to kiss your hand. I cannot better enforce my idea of the wished-for cleanliness, because I want you to operate on this salad with your fingers, and to allow no knife, fork, or spoon to come between you and the preparation of it.

I will suppose the vegetable to be lettuce, and I shall ask you to carefully dry it. This you may do by swinging it about in a wire basket, but I always consider that the most effectual way is to throw the leaves into a clean cloth and shake the cloth, or swing it from front to back, stopping with a jerk, and so the cloth will take up all the watery contents.

I shall now ask you to break the leaves with your fingers. I do not advise mixing cress, &c.; but if you like onions, merely rub the salad-bowl with one. The leaves so broken you will place in the bowl, and proceed to apply your cream or oil. Of these I hope it may be oil of the best, and I beg you to mix and turn it, always with your fingers, until every particle of the vegetable has a facing of oil.

You should now have your salt-dredger by you, and you

should sprinkle the leaves lightly, using the greatest judgment in not overdoing it.

With the pepper-mill, a recent but most happy invention, you should apply the black pepper as you have done the salt, most tenderly.

You now come to the application of the vinegar. The quantity of this is purely a matter of taste, and you must consult the tastes of those in the dining-room; but whatever amount you are to apply, it should be done in detail. For this I have devised the use of one of those modern bottles with a peculiar stopper, such as the vendors of Tabasco sauce, or, in fact, any chemist who sells eau-de-cologne, will supply, which only permits you to fling out the contents drop by drop. With this you can apply your vinegar in detail to the several leaves or parts of your salad. Coming on the top of salt and pepper, already applied, an agreeable chemical action is produced.

But you have not finished. Still with your hands alone will you turn and re-turn the precious mixture, and you will send it up with every leaf and particle saturated with this combination of oil, acid, and condiment.

I should add that most homes where salads are prepared require bowls of different sizes. It is, for instance, a very small one that will do for preparing a salad for two, but, if you have ten persons at the table, the case is very different. There is one friend's house where I am often asked to prepare a salad for a large number, and I am obliged to make it in two bowls. As the proportions are never exactly the same, I always consider that the criticism I hear does not touch me, for I never know of which bowl the critic is speaking. One says "a little too much salt," and another "too much oil."

CONCLUSION.

In compiling this Handbook, it has not been necessary to offer an opinion on matters of mere taste. Indeed, had it

been, I should have prefaced any suggestions I might have had to make by the words I used elsewhere, when a wider latitude was allowed me in criticising the views of others. I said then, as I say now, "we must readily admit that there is no infallibility in dogmas directed against other people's stomachs." But in saying this, I am not prevented from pointing out those cases where a people (our people) have been led away from correct taste by the bountiful provision of fuel which Nature has given us.

It is not too much to say that with coal at five pounds a ton, cookery could never have fallen to the low ebb which the School of Cookery has been established to correct. In France first, and in Italy afterwards, where waste in fuel means ruin to a household, dishes are cooked by the humblest which you would gratefully seize if they appeared on the *menu* of the best club in London.

I mean by this that Fire, although an essential, may be very badly and foolishly used, and that the very difficulties in the way of those who have had to pay dearly for it, have assisted in creating the greatest national school of cookery that has ever existed. I speak of France.

I will not permit it to be said that I am advocating all the results that flow from that indigenous school, but I maintain that the processes it employs—that are employed throughout France among the lower middle-classes—involve a quality of food and economy that are not obtained in our cottages; and until a *pot-au-feu*, or its equivalent, is an institution with us, we shall not know what it is to have a national dish. Finally, let the cook be modest, and with that he or she will have a greater chance to obtain the inspiration of GENIUS.

DIET IN RELATION

TO

HEALTH AND WORK.

BY

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PREFACE.

THIS brief treatise was at first advertised under the title of 'Food,' but the title has been changed to that which it now bears, for fear lest there be any confusion between 'Food,' and 'Foods, their Composition and Analysis,' which latter is a work of an entirely different scope.

The design of the present "Handbook" is to give a clear, popular, and concise exposition of the composition and nutritive powers of the chief foods, and the general principles of diet.

Special Handbooks belonging to the same series having been prepared by other writers on such accessories to food, as alcoholic drinks and condiments, a description of these has been omitted.

I have for the most part given the components of the various forms of nutriment in the familiar household weights of pounds and ounces as well as percentages. The composition of a great many foods—limited space forbidding a full description—will be found tabulated in the Appendix.

Court House, Marylebone,
May, 1884.

CONTENTS.

DIVISION I.

FIRST PRINCIPLES—FOOD AND WORK.

CHAPTER I.

MOLECULAR LIFE.

CHAPTER II.

SUGAR STORES—FAT STORES.

CHAPTER III.

THE WORK TO BE DONE.

CHAPTER IV.

A MATHEMATICAL FORM OF EXPRESSION FOR VARIOUS KINDS OF LABOUR.

CONTENTS.

DIVISION II.

FOOD EQUIVALENTS.

CHAPTER V.

DIVISIONS OF FOOD.

CHAPTER VI.

WATER.

CHAPTER VII.

CARBOHYDRATES.

CHAPTER VIII.

FATS.

CHAPTER IX.

THE NITROGENOUS, ALBUMENOUS OR MEATY SUBSTANCES.

CHAPTER X.

ACCESSORY FOODS—LUXURIES.

CHAPTER XI.

MINERAL MATTER.

CHAPTER XII.

DIGESTIBILITY OF FOOD, OR INCOME AND OUTPUT.

DIVISION III.

FLESH AND MILK.

CHAPTER XIII.

MEAT.

CHAPTER XIV.

FISH.

CHAPTER XV.

TINNED FOODS.

CHAPTER XVI.

MILK.

CHAPTER XVII.

BUTTER.

DIVISION IV.

CHIEF SOURCES OF THE CARBOHYDRATES.

CHAPTER XVIII.

BREAD—FLOUR.

CHAPTER XIX.

OATMEAL—BARLEY MEAL—RYE MEAL.

CHAPTER XX.

MAIZE OR INDIAN CORN.

CHAPTER XXI.

RICE.

CHAPTER XXII.

THE POTATO.

DIVISION V.

LEGUMINOUS VEGETABLES—SUCCULENT VEGETABLES AND FRUITS.

CHAPTER XXIII.

LEGUMINOUS VEGETABLES—PEAS—BEANS—LENTILS.

CHAPTER XXIV.

SUCCULENT FRUITS AND VEGETABLES.

DIVISION VI.

ALKALOID-HOLDING DRINKS.

CHAPTER XXV.

TEA, COFFEE, COCOA, AND CHOCOLATE.

DIVISION VII.

THE PRINCIPLES OF DIET.

CHAPTER XXVI.

THE PRINCIPLES OF DIET.

APPENDIX.

DIET

IN RELATION TO

HEALTH AND WORK.

DIVISION I.

FIRST PRINCIPLES—FOOD AND WORK.

CHAPTER I.

MOLECULAR LIFE.

Description o the smallest molecules of life.

§ 1. THERE are little masses of jelly to be found in ponds and brooks which possess the power of digesting without a stomach, of breathing without lungs, of feeling without nerves, of moving without muscles, and of multiplying without marriage. A few of these jellies develop into higher forms of life, others, as they commenced, so they complete the cycle of their existence; among the latter is a common microscopic object called the amœba. In strict biological language the amœba is described as composed of "*undifferentiated protoplasm*" (protos, first; plasma, form), that is, a *first-form*, no single part of which differs from any other part. The amœba takes its food by flowing round the substance, embedding it in the jelly of its body, and thus at once digesting and swallowing. After a time those portions which it cannot assimilate are ejected. The amœba breathes by absorbing oxygen from the dissolved air in water, and excreting it as carbonic acid; it is in a continual flux, for pushing out first one part and then another, it

moves, or more correctly "flows," from place to place. It propagates its kind by simple buds, a little bit becomes detached, starts life on it own account, and like its parent, lives, grows, moves, eats, buds and dies, having been the whole period nothing but a shapeless little mass of protoplasm.

Man but a community of protoplasmads (plastitudes).

§ 2. Now the higher animals, including man, the highest of all, are but a collection—a multitude or a crowd—of just such minute masses of protoplasm, the nearest approach to the amœba being seen in the white corpuscles of the blood, which, when examined under proper conditions, can be observed, even when removed from the body, to be in shape, structure, and automatism precisely like the amœba; while the farthest from the amoeba is perhaps seen in the corpuscles of bone.

Division of labour.

The greatest number of the amœba of the body have lost the power of moving from place to place, but rooted to one spot, have acquired special functions. The amœba or protoplasm of bone, develops or secretes from the nourishment brought to it, bone; that of muscle, muscle; that of cartilage, cartilage. The stationary masses of protoplasm are nourished by those that are moving, and thus receive not alone fluid but gaseous substances; the red corpuscles of the blood each bring a tiny load of oxygen from the lungs, deliver the oxygen up to the tissues, go back to the lungs again to take another load, and so on for ever. This process is easily realised by anyone who has seen a beautiful experiment of Schutzenberger's. A tube of gold beater's skin is immersed in active growing yeast, and bright arterial blood, that is, blood with each of its red corpuscles containing, as in a little boat, a tiny load of oxygen, passed slowly through the tube; the blood comes out at the other end dark and venous; that is, it has delivered up to the living yeast cells its oxygen, just as in the body it delivers its oxygen up to the tissues.

The city of the body.

§ 3. Hence each human unit is in himself a small cosmos, a peripatetic city; at the gates of sight, odour, feeling and hearing, stand sentinels; along the fluid high-

ways float with the stream oxygen-laden boats, discharge their cargoes, and return, and along the same channels flow the food of the inhabitants. In every day and night there are many births and many deaths. Each citizen has his appointed place and avocation ; those in the liver manufacture the bile and glycogen ; those in the brain store up as in a Fauré-battery the nervous force ; high up in the tower, beneath a thatch of hair, sit two rulers, the one a *Geist* or intelligence, the other a sleepless automaton ; the office of the higher is the direction of what are called voluntary acts ; the office of the lower is to see to the tick tick of life, the ebbing and flowing of the tides of secretion.

We have to study how this city, the city of the human *Bios*, has to be fed, the composition of the food, its distribution and assimilation.

CHAPTER II.

SUGAR STORES.—FAT STORES.

Discovery of glycogen.

§ 4. Claude Bernard made several years ago the important discovery that the blood coming from the liver was more rich in sugar than the blood going to the liver; and further, that the origin of this sugar was a starch-like substance which he isolated and extracted from the liver as a snow-white powder. He called it *glycogen** because it was readily transformed into sugar. If an animal is starved, its glycogen rapidly disappears, but if it is then given food rich in starch, the glycogen is rapidly renewed and is again found in the liver. This remarkable fact is explained by modern physiologists by supposing that the liver is a great store-room for sugar, that the blood must be maintained at a certain average composition, that many organs and tissues are constantly drawing on the blood for sugar, and that when the blood is thus deprived of its sugar, the deficiency is supplied from the great sugar store-house, the liver; when, on the other hand, we eat sweet things or starchy things in excess, instead of all this being thrown into the blood, it is treasured up for a time of need. Besides the great store-house of glycogen there are little private supplies, as it were, in the muscles themselves.

The liver a store-room for sugar.

Fat stores.

In the same way is garnered up "fat." It is not collected in one or two places, but, with the exception of certain parts which never become fat, is stored up very generally, especially beneath the skin and in the abdomen.

* Glycogen is a word derived from the Greek: glukus, sweet; gennao, to produce or engender.

CHAPTER III.

THE WORK TO BE DONE.

§ 5. The body never rests; in the long-continued deep sleep, occasionally met with, in which a person from some affection of the brain sleeps quietly for weeks, there is still work to be done, and unless suitable food be administered death will ensue. Such work is presided over by the automaton (p. 265), is independent of the will, and is called "internal work." It consists of the maintenance of the temperature of the body, of the maintenance of the heart's beat, of the respiratory wave, and of various minor reflex actions. Whereas "external work" consists in all voluntary acts whatever—standing, sitting, walking, running, thinking, talking, etc.

The never-resting organism.

External work.

§ 6. In my laboratory I have an incubator heated by gas, which I am enabled to keep at a constant temperature by means of a mercury governor. If the incubator gets hotter than required, the mercury rises and cuts off partly the supply of gas; if the incubator cools, the mercury falls; and a larger supply of gas—a larger flame—is the result. Night and day the incubator for many weeks is automatically kept within half a degree of the required heat; something like this goes on in the body, but the heat regulating automatism of the body is far superior to the heat regulating automatism of any artificial mechanism. In all climates, whether under the tropics or the poles, the temperature of the body remains at 98·8° F., or at the most one or two tenths above or below that temperature. Heat is lost to the body by evaporation from the skin, by the warming of the air we breathe, and a small quantity is also lost by all excretory matters leaving the body. Heat is given to the body by the chemical and vital changes going on. In cold

Heat equilibrium.

weather, there is greater metabolism* than in hot, and therefore a greater production of heat. It is in this increased metabolism in cold and diminished metabolism in hot, that the warm-blooded animals differ so much from the cold-blooded animals ; a frog has a temperature about that of the surrounding air, and in summer is hotter than in winter. By estimating the carbonic acid gas the frog exhales under different temperatures, it is possible to know whether the frog's metabolism is like ours, increased during cold weather, the result of the experiment is that it is diminished by cold, increased by heat ; in other words the frog behaves in this respect like a mass of dead organic matter, which decomposes quickly in hot weather, slowly in cold, while in our case it is quite the reverse.

§ 7. It is obvious that, since the food taken in and the metabolic changes in the tissues are very different at different times, and the temperature of the air is never maintained at the temperature of the body for any time, the mechanism must be very perfect to maintain the "heat equilibrium."

Regulators of heat.

The great regulator is the skin. If by exercise, or by external heat, the cutaneous vessels become dilated and filled with blood, there is a greater radiation of heat, and the perspiration is poured out, which by its evaporation cools the body ; on the other hand, cold, by constricting the vessels, causes a smaller flow through the skin, and a larger flow through the viscera, but besides the skin there is a nervous centre which regulates the production of heat, more or less heat being produced according to the wants of the body.

Heat-giving foods.

§ 8. The foods that give heat are the carbohydrates and the fatty, more especially the latter, hence in cold climates the large amount of fat used. The Esquimaux, the Tartars, the Fins, the Laps, the Patagonians, all from necessity devour enormous quantities of fat.

* Metabolism is a word derived from the Greek Meta-ballô ; its original meaning is "change" or "transposition ;" it is a convenient term by which to express "tissue change."

§ 9. The origin of muscular force has been hotly disputed. Liebig had a very strong opinion that meaty or nitrogenous substances went to feed the muscles; but this idea is no longer held, although at first sight it has so much in its favour. Everyone, for instance, knows that a highly nitrogenous diet is necessary for hard labour, that the labourer, if he can get it, eats plentifully of meat, and that the diets of training for athletic feats are also very "meaty." **Origin of muscular force.**

It is possible to examine living muscle itself, both at rest and in action, and to collect the products, gaseous and other, which are given forth; but when thus examined no nitrogenous body is set free, but on the contrary, carbonic acid gas, the same gas as in the burning of a candle or the burning of coal. We also find that a man in exercise and the same man in repose exhales very different amounts of carbonic acid gas. Thus one at work was found to consume in 24 hours 954 grms. of oxygen and to produce 1284 grms. of carbonic acid, but when at rest 708 grms. of oxygen and 911 grms. of carbonic acid; this man's nitrogen was not increased. This then teaches us, (1) that muscle during its action does not exhale any body containing an appreciable amount of nitrogen; (2) that it does exhale carbonic acid, just as if it breathed; (3) that in the excretions there is no increase of nitrogen beyond that consumed.

But although these are facts, yet for all that, strong exercise requires nitrogenous food. What is the reason? No decided answer, no answer that can be absolutely demonstrated by experiment, can be given; but there is probability in the view that the nitrogenous foods break up into urea, and a body nitrogen-free (in great part in the intestinal canal). The nitrogen-free body goes to form fat, which in turn is used up as a muscular fuel, and the carbon is excreted in the form of carbonic acid, just as a candle burning transforms the whole of the candle fat into carbonic acid and water; another part of the nitrogenous food possibly goes to renew the red blood corpuscles, which in strong exercise have much to do, conveying oxygen to the air-thirsty, eager, labouring tissues. We have then seen that **The breaking up of the meaty substances.**

the fats and carbohydrates are the remote sources of animal heat; that the nitrogenous foods are indirectly the support of the muscular system; but there is a third element to be supported—the highest of all—the nervous tissue. The nervous tissue is a most complicated structure; it contains very much water, it is built up of albumenous matter, and contains another element of which we have not spoken before, viz. phosphorus. If it were true that muscle made muscle, that fat made fat, then to stimulate our nervous system, to exalt our brains, we should live on the marrow of bones, the cerebral matter of animals, and the roe of fishes, for all these are substances rich in organic phosphorus; but if it is not clear in what way the muscles derive their energy, it is still less clear to what principle or food is to be referred the nervous force. All that we know is, that which keeps the bodily functions in the highest health is also good for the brain; the interdependence between bodily and nervous energy is so great that one can never suffer without the other more or less participating.

Food of the nervous tissues

CHAPTER IV.

A MATHEMATICAL FORM OF EXPRESSION FOR VARIOUS KINDS OF LABOUR.

§ 10. For comparing the values of foods as force producers, it is necessary to reduce all work to one common standard, in other words to reduce or convert the various kinds of labour, such as walking, climbing, pulling, rowing, carrying weights, wielding hammers and axes, into the same sort of work. This standard work is always referred to lifting a known weight. In order to fully understand this, you have only to suppose a hundredweight attached to a cord going over a pulley; now it is obvious, that neglecting friction, since there are 20 cwt. in a ton, if you lift by pulling at the string the weight exactly 1 foot off the ground and let it fall again, and do this 20 times in the day, the day's work will be accurately expressed by saying that you have lifted 1 ton 1 foot high; and the standard used in this country for expressing work is so many tons or pounds lifted 1 foot high. The mechanical equivalent of work.

The internal work, that is, the work done by the heart and generally automatic labour, is estimated at so high a figure as 260 foot-tons; the external work varies much; a country postman, 150 lbs. in weight, walking his daily round of 20 miles, would do work equal to 353·4 foot-tons; ordinary day labourers, such as we see in the roads, probably average 350 foot-tons. In the case of a pedlar cited by Parkes, who carried 28 lbs. on his back and walked 20 miles daily, the work was 419½ foot-tons. Internal work. External work.

In Weston's feat of 50 miles a day, I have calculated his daily work to be no less than 793 foot-tons, but this large number was exceeded in a former feat in which he walked 317½ miles in 5 days, which would give approximately 1010 foot-tons daily.

A very hard day's work for most men is 400 foot-tons. At the other end of the scale stand the sedentary occupations, e.g., needlewomen; the external work of such may fall as low as 17 or 18 foot-tons.

The mechanical equivalent of heat.

§ 11. If the concept is difficult to those to whom these calculations are new, of expressing all manner of action as so much weight raised a certain height, the concept of expressing the latent power of various foods in the same way is still harder to grasp. I hope, nevertheless, to make the principle clear. Primitive man obtains fire by rubbing two sticks together, in other words he transmutes the force of motion into the force of heat; what the primitive man does for his necessities the scientific man has done for the advancement of knowledge. Joule and others have measured accurately the amount of friction necessary to raise a certain weight of water 1 degree of temperature; 1 lb. of water is raised 1° F. by an amount of force sufficient to raise 772 lbs. to the height of 1 foot, and this is called "*the mechanical equivalent of heat.*"*

The carbon and the hydrogen taken into the body are more or less burnt up, the one to carbonic acid gas, and the other to water. In this process they develop heat, and this heat can from the data just given be easily expressed in terms of the "mechanical equivalent of heat." The heat produced in this way by the union of oxygen is capable of experimental determination; in particular, Prof. Frankland a few years ago made some very valuable experiments and determined the energy developed by a known weight of a number of foods when burnt in oxygen.

Potential energy of food.

				Foot-tons.
An ounce of	cabbage,	equalled	. . . .	16
" "	carrots,	"	. . . .	20
" "	milk,	"	. . . .	24
" "	lean beef	"	. . . .	55
" "	ground oatmeal	"	. . . .	152
" "	butter	"	. . . .	281

* Expressed in terms of the metrical system, this means that "a unit of heat, that is, the heat capable of raising 1 grm. of water 1° C., is equivalent to a force which would lift 423·55 grms. the height of 1 metre."

Very similar numbers have been obtained by calculation, that is, from the known amounts of carbon and hydrogen in the food. Just the same as in a steam engine the theoretical amount of steam is never obtained from a given weight of coal, so in the body this theoretical amount of force is never realised; the reason being that part of the carbon and hydrogen passes away unconsumed. But by carefully estimating these unburnt residues and subtracting them from the food, a knowledge of the available energy may be obtained. Unless this is done, a charcoal biscuit would on purely chemical grounds have a higher value ascribed to it than the same weight of an ordinary biscuit—besides, it is to be remembered that not alone must the food be digested but its energy applied at the proper place, so that the problem of determining the potential energy of a food is very complex and demands a number of exact experiments.

DIVISION II.

FOOD EQUIVALENTS.

CHAPTER V.

DIVISION OF FOODS.

Ultimate office of food.

§ 12. In the first chapter, the little protoplasmic masses, the tiny lives whose aggregate makes tissue, tendon, nerve, skin and muscle, have been described, and it has been explained that the ultimate object of all food is their nourishment. It necessarily then follows that any substance whatever that nourishes one of these micro-lives is a food. Since the tissues of the body can only be reached by circulating fluids, food must be first converted into a state suitable for absorption, so as to be conveyed by the circulation to wherever it is required ; bread and butter, potatoes and meat, all have to be comminuted by the mill of the teeth, moistened by the saliva, fermented and dissolved by various juices, and reduced to the level of a common fluid : for it is obvious that such minute channels as the finest blood and lymph vessels can only convey fluids or particles of excessive minuteness.

§ 13. Foods are scientifically divided into—

Divisions of foods

1. Water.
2. Meaty or albumenous substances.
3. Starches or Carbohydrates.
4. Fats.
5. Mineral matters.
6. Accessory foods.

All of which have their representatives in the body itself.

A human being is so "watery" that the corpse of a man weighing 150 lbs., and carefully dried, would come out a shrivelled mass of about 50 lbs. in weight; the meaty substances are represented by muscle, the starchy by glycogen found in the liver, and by a sugar [*inosite*] found in the muscles; fat is present, padding angular parts and giving a roundness to the frame; mineral matters abound, especially in the bones and teeth.

Human body contains 66·6 per cent. of water.

The New Zealand native had a ferocious way of gouging out his sharp-sighted enemy's eye and swallowing it; this because he thought that such an act would give him clear sight which had resided in that eye; a very similar popular view is held by many people with reference to food; they think that if you want muscle, you must eat muscle, that fat makes fat, and that mineral matters make bone; but in these popular notions there are many errors—errors which I hope will be made clear in the subsequent pages.

The composition of the human body is somewhat as follows:—

Composition of the body.

ADULT MAN.

Bones	16 per cent.
Muscles	42 " "
Organs in the chest and abdomen .	9 " "
Fat and skin	25 " "
Brain	2 " "

Therefore supposing a person weighed 150 lbs. (ten stone ten pounds) 63 lbs. would be muscle, 37½ lbs. would be skin and fat, 24 lbs. would be bone, and 3 lbs. would be brain.

More than half the weight of the body is bone and muscle.

§ 14. Important information as to the office of food is afforded by two states—starvation and hybernation. When an animal is starved, the glycogen in the liver and the fat are the first to disappear, the abdominal organs then waste, but the muscles do not so much diminish, while the brain and spinal cord keep the same weight as

Hybernation and starvation

The master tissues.

before. Thus muscular and nervous tissues are the ***master tissues*** of the body, the others are their servants.

In hybernation the same phenomena are seen: on waking from the winter sleep the fat and glycogen have been used up, and the first thing the animal does is to renew both by food.

CHAPTER VI.

WATER.

§ 15. It is hardly to be realised that water essentially consists of the combination and condensation of two gases, hydrogen and oxygen in the proportion of two volumes of hydrogen and one volume of oxygen, represented by the chemical symbol H_2O; but few scientific facts are so well established. **The composition of water.**

In our food and tissues there is much water, part of it is in such a loose state of combination that it is usually described as *free*, but part is in a more intimate union. This will perhaps be better understood if I take an example from the mineral kingdom, say some crystals of common alum; if we sprinkle some water upon these crystals, and place them in a dish on the top of an oven which is kept at the heat of the boiling-point of water, the crystals rapidly become in popular language dry; but they still contain water—a water which bears a very definite and constant weight to the weight of the crystals, a water which to be driven off completely requires a higher heat than the water that was sprinkled upon them; and when it is at last driven off, the crystals lose their shape and crumble to a powder—so in all food that we eat, and in the body itself water is in two different states, in the one state merely soaking and imbuing the tissues or the basis of fluids, and in another state altogether, forming an intimate part and only to be got rid of by altering essentially, almost destroying, the structure.

§ 16. The amount of water in food is very large. A beef-steak contains 75 per cent. of water. In buying a pound, only one fourth of that pound is dry solid meat. Cabbages contain 85 to 90 per cent. of their weight of water, and succulent fruits sometimes more than 90 per cent. Of **Amount of water in foods.**

substances most commonly eaten, rusks or biscuits are the driest, and water-melons the most watery of foods.

Purposes which water serves.

§ 17. When water is taken into the system it assists without doubt in the building up of new tissues, in the repair of old. According to this view it is not merely a dilutent of fluids, it does not simply play an inactive part like a lubricant of machinery, but is in the truest sense a food. There are plenty of experiments—both involuntary experiments, as among shipwrecked people, and experiments made for the purpose of experiment—showing that so long as water is taken, the deprivation of all other food can be supported for a very long time. When deprived of food and water, it is the latter want we feel most and soonest. The sensation of thirst is felt in the mouth and throat; but it has been abundantly shown that, however much water the throat is laved with, unless the water is actually swallowed, thirst continues: e.g. in a case recorded by Dr. Gardiner, a man had a wound in the throat so placed that all liquids escaped through it; the man drank huge quantities of water, but without any alleviation; he was in the position of Tantalus, and suffered much—nevertheless, sailors shipwrecked and in extreme thirst have found some little relief by dipping or rather soaking themselves in the sea, so that it would seem that the skin is capable of absorbing some small quantity.

To quench thirst water must be absorbed.

Amount of water required daily.

§ 18. The amount of water taken as water or in the shape of liquids—such as tea, coffee, soup, beer, and the like—varies much according to climate, exercise and custom; in our own climate, it may be put at two-and-a-half pints daily, as a sufficient quantity—the water naturally in food may amount to about two pints, making a daily total of four-and-a-half pints.

CHAPTER VII.

CARBOHYDRATES.

Sugar and starches.

§ 19. The type of the carbohydrates is sugar or starch, and the composition of both sugar and starch is simply that of a union of carbon and water—hence its name, carbohydrate. That sugar or starches do contain charcoal and water, may be shown by simply burning a little sugar in a spoon; the blackening shows the charcoal or carbon; a dish filled with water to keep it cool, held over the burning sugar, will show a moisture of the bottom, which at all events proves that either water was originally present or was produced in the act of burning; if the heat is continued nothing will remain in the spoon, the water has gone off as water, and the carbon has united with the oxygen of the air to form a colourless gas (carbonic acid gas); and as there are no mineral constituents in either pure sugar or pure starch, no ash or saline residue remains. The chemical formula for starch is $C_6 H_{10} O_5$ or six atoms of carbon united intimately with five atoms of water ($H_2 O$); the chemical formula for cane-sugar is $C_{12} H_{22} O_{11}$ or twelve atoms of carbon united with eleven atoms of water. It then follows that the percentage composition of starch and sugar is the same, that is, they each contain the same weight in 100 parts of carbon, hydrogen and oxygen, thus:

			Per cent.
Carbon		. . . . . .	44·45
Hydrogen	6·06	Water . . .	55·55
Oxygen	49·49		

The four chief carbohydrates.

§ 20. The four chief carbohydrates taken in food are ordinary cane-sugar, glucose, sugar of milk, and starches, such as wheat starch in bread, oat starch in oatmeal, rice starch in rice, &c. Though these have practically all the same centesimal composition, and may be presumed to be

to a great extent mutally replaceable, and to subserve the same functions in the body; yet cane-sugar and starch are by no means alike, either in form, taste, or even in chemical reactions. It is, however, no surprising thing for substances to be identical in the percentages of their ultimate carbon, hydrogen, and oxygen, and yet to be very different things. The carbohydrates are transformed in the mouth, in the stomach, and in the intestines to some other body, the exact nature of which is not known.* When a small quantity of starch or sugar is given daily, the results of careful analyses made of the total carbon going into the body, and total carbon going out as refuse products, have shown that under such circumstances, a condition of *carbon equilibrium* is established—that is, the exact amount of carbon going into the body also leaves the body; none of it is garnered away. On the other hand, if a plentiful supply of carbohydrates is given, the store-house of the liver becomes rich in glycogen, and at the same time there is an increase of fat. In this case careful analyses show that the amounts of carbon going into the body exceed the carbon going out of the body. There is therefore no carbon equilibrium, the body increases in weight; the store-houses become full.

Digestion of carbo-hydrates.

Carbon equilibrium.

* Dr. Pavy's researches have clearly demonstrated that in animals there is a ferment in the stomach and intestines which acts on carbo-hydrates in a peculiar way.

CHAPTER VIII.

FATS.

§ 21. All the common fats we eat, such as butter, lard, dripping, and the fats of various meats, are absolutely neutral, that is, there is no free acid; on the other hand, vegetable fats, or oils, are seldom perfectly neutral, but contain usually some free fatty acid. The neutral fats are rather complicated bodies, splitting up under the action of superheated steam, or of a strong alkali like potash, into one or more fatty acids, and into glycerin. **Composition of fat.**

The fat, when it reaches the first part of the intestine, becomes emulsified by the action of the juice of the pancreas or sweetbread, and other juices, and is absorbed into the circulation as fat. It is believed to be partly burnt up, as it were, in the muscles, and if in moderate excess of the actual requirements, it is like glycogen stored up ready for emergencies.

§ 22. Fat is not formed entirely from fat. Lawes and Gilbert gave a pig, with other food, one hundred parts of fat, but the fat produced in the pig was four hundred and seventy-two parts, or almost five times as much as was given. The general view is now that fat is formed in part from fat, in part from carbohydrates, and in part from meaty substances. **Formation of fat.**

That the carbohydrates can produce fatty matters is well shown by the experiments of Erlenmeyer and Plantan-Reichenbau who fed bees on pure sugar and water, but they still produced wax.

CHAPTER IX.

THE NITROGENOUS, ALBUMENOUS OR MEATY SUBSTANCES.

Composition of albumen.

§ 23. The albumenous foods are so called because their type is the white or albumen of the egg. The albumen of the egg, besides containing carbon, oxygen, hydrogen, and a little sulphur, also contains nitrogen. Nitrogen itself is a gas, without odour or taste; it is, in fact, the main constituent of the atmosphere, diluting oxygen. Each person from the beginning to the end of existence is immersed in a great gaseous ocean of nitrogen; but however indifferent it may be in the gaseous state, when it enters into chemical combination with carbon and hydrogen it makes at once the most potent foods and poisons known. All the important functions of the body are carried on by nitrogenous fluids or solids. The muscles abound with nitrogen; the brain, the nervous system, the blood, all the fluids of the body, and all the cells contain nitrogen, not as an accidental but as a leading character. Nitrogen is so intimately associated with life, that wherever it is found in combination it would seem to be a sign of either present or past life.

Life cannot be maintained on pure starch, sugar or fat for a long time; on the other hand, a purely meat diet can maintain life indefinitely.

Urea.

§ 24. The nitrogen of the food appears to leave the body in the form of a substance called urea, which is dissolved in the urine; some of the nitrogen, it is true, leaves the body by other channels, and under other forms, but the main channel is through the kidneys. It would be only natural to suppose that, with so many parts of the body nitrogenous, there would be much nitrogen to be continually replaced; that in violent exercise, for instance,

or intense brain-work, the nitrogenous molecules of the muscle or brain would be broken down in proportion to the work done, and have to be replaced by nitrogen from outside. Curiously enough, we have no proof of this, all the evidence goes to show that the excretion of nitrogen has very little relation to the work done, but very great relation to the amount of nitrogen taken into the system as food. It is true that there is a certain daily excretion of nitrogen as urea, an excretion bearing a definite relation to body-weight; but nevertheless, a number of careful experiments have shown very conclusively that nearly all the nitrogen taken as food leaves the body as urea, and that the nitrogen rises and falls whether hard work is done or not according to the nature of the food.

Intake and outgo of nitrogen.

§ 25. A nitrogenous diet increases the red corpuscles of the blood, those bodies which I have before likened to little oxygen-laden boats, and it also increases very largely the metabolic changes of the body. Perhaps this is dependent on the increased oxygen-carrying power; however this may be, the success of the so-called Banting system depends in some degree upon the great stimulus that an excessive meat diet gives to the tissue changes.

A meat diet increases tissue change.

CHAPTER X.

ACCESSORY FOODS—LUXURIES.

The accessories of food.

§ 26. Certain foods, the use of which we hardly know, have been thrown into a single class, and called "accessory foods." It is, under the circumstances, of course a most miscellaneous collection, and a higher knowledge of the functions of food will, it is hoped, differentiate the members; it includes such substances as tea, coffee, alcoholic drinks, pepper, and spices. We probably could do very well without them, but yet they seem in some way useful; they are the luxuries of diet. Such substances have been compared by those who have likened the human body to an engine, to the lubricating oil of machinery, making everything smooth and easy, stopping creaking and jarring. I have, however, been careful neither to liken the body to an engine, nor to copy Pettenkofer in likening it to a mill, for these conceptions, besides being faulty in themselves, consider the human body too much as a simple entity, whereas, I rather insist upon the more scientifically correct view that the human body is a collection of living units and life the sum-total of myriads of micro-lives.

Many of the so-called "accessory foods" are probably used in some way by the nervous system. This is specially the case with tea or coffee; a cup of strong coffee often removes the sense of muscular and mental weariness like a charm. We shall perhaps be able to divide the "accessory food" class hereafter into two, viz., the one a "nutrient alkaloidal" class, the other a "peptic" or digestive class.

Alkaloidal and peptic foods.

In milk, in extract of meat, in tea, in coffee, there are either true alkaloids, or bodies which stand between the albumenoids and alkaloids, which from the constancy of their presence are probably in some way subservient to nutrition; these I may provisionally call "nutrient alkaloidals." On the other hand pepper, small quantities of alcohol, malt extract, and the like, would belong to my "peptic" class, for they assist digestion.

CHAPTER XI.

MINERAL MATTER.

§ 27. In the pipe bowl of the earth, a slow oxidation by means of the air goes on for ever; beast and bird, king and peasant are burnt up, nothing remains but an ash. The phosphates of lime, magnesia, the chlorides of potassium and sodium, a little iron, silica, fluorine and a few other similar substances, may be mechanically dissipated, but preserve their form, when brain and nerve, muscle and all else that has built up the fabric of life has been totally changed to gaseous or fluid elements. It would seem that certain proportions of these mineral substances are necessary both for the development of growth, and for the maintenance of health; the chicken in the egg has some power of assimilating its outside case of lime, the case gets thinner and thinner, and goes to form the inner skeleton. There is an experiment on record in which pigeons were fed on wheat deprived of all mineral matter; after three months the bones became extremely thin and fragile, and parts of the breast bone disappeared, as though the *master-tissues* must have their lime and magnesia from any source, and not getting it from the outer world, feed upon the inner. Nature's cremation.

§ 28. The only mineral matter that man craves for is salt, all the rest is taken in sufficient quantities with the daily food; a few substances such as sugar, rice, arrowroot and starch, are either ash-free, or contain so small a quantity as to be unimportant sources, whereas meat, fruits, and vegetables, abound in "ash." The craving for salt.

The common bending of the legs and spine in rickety children, is usually ascribed to a deficiency of phosphates of lime in the food; but this is erroneous; it is rather due to want of power of those parts of the body to assimilate the proper mineral substances submitted to them. The, explanation of the desire for common salt, is to be found in the fact that it is essential to all the fluids of the body—the blood, the lymph and the chyle. Rickets.

CHAPTER XII.

DIGESTIBILITY OF FOOD, OR INCOME AND OUTPUT.

Digestion and its imperfections.

§ 29. Digestion is in no animal perfect; if it were so that which passes away would be a residuum wholly without nutriment, but this is so far from being the case, that the dung of the higher animals is a food to countless insects and to many species of birds. As the stoker of a steam-engine has to supply an excess of coal over and above that required theoretically to start the mechanism and to maintain it in motion, so have we all to eat an excess of food over and above that which, if the digestive organs were perfect extractors of the food, would nourish the body.

The various degrees of digestibility of foods have been found out in the following ways:

1. By experiments in the laboratory; the chemist submitting different foods to the action of the juice of the pancreas, of the stomach, &c., at a regulated heat for a regulated time.

2. By experiments on the human body, in those rare cases in which a fistula or opening leading into the stomach has been caused by disease; or, in healthy people, watching the stages of gastric digestion by the removal of the products by the stomach pump.

3. By experiments on animals in which an artificial opening into the stomach has been made.

4. By analysis of the "income and output," i.e., of the food going into the body, and of the food residues (excreta) which pass out of the body.

Of all these methods the last is by many degrees the most certain, for no unnatural condition or element is introduced; besides which, a food residue, which has passed the length of the whole canal, may with more confidence have its value subtracted from the food, than a food residue

which has only been submitted to the action of a small portion of the canal.

§ 30. The most indigestible things are vegetable substances abounding in woody fibre, the most digestible are substances like sugar, extremely soluble—the "hips and haws" that children pick from the hedges, and "sweets" are thus examples of the two extreme terms of a list of substances arranged in order of their digestibility.

The following list of substances is arranged according to the results obtained by various experimenters,* those foods giving the least amount of waste products occupying the top of the list, those giving the most being placed at the bottom—that is, arranged according to their power of being digested; but it is not to be inferred necessarily that

Digestible and indigestible foods.

	Parts digested of 100 parts of the perfectly dried solid.	Amount of solid food residue passing away from the body by the alimentary canal.
Sugar	100·00	
Rice	96·00	4·00
Wheaten Bread	95·00	5·00
Roast Meat	94·80	5·20
Hard boiled Eggs	94·75	5·25
Milk and Cheese (in the proportion of 2·4 : 1)	94·00	6·00
Cornflour	93·30	6·70
Milk and Cheese (in the proportion of 2 : 1)	93·20	6·80
Milk, 830 parts of fluid = 100 of solids.	91·00	9·00
Potatoes	90·60	9·40
Rye Bread	88·9	11·1
Milk and Cheese (equal parts of dry solids)	88·7	11·3
Black Bread	83·0	17·0
Carrots, Celery, Cabbage	76·0	24·0
Peas, Beans, &c.	52·4	47·6
Gelatin	50 0	50·0

* In particular, the experiments of Rubner, 'Zeitschrift f. Biologie, 1879,' S. 118; of G. Meyer, 'Zeitschrift f. Biologie, 1871,' 1; of A. Strümpell, 'Centrbl. f. Medicin. Wiss. 1876,' S. 47; and of H. Weiske, 'Zeitschrift f. Biol., 1870,' S. 456.

foods occupying the lower portion of the list will cause those unpleasant symptoms known as "indigestion" or dyspepsia, a condition induced by various causes and which may arise from all kinds of food—but the word "digestion" is used here rather in a physiological sense, that is, *digestible foods* of which small solid residues leave the body, *indigestible foods* of which the solid residues are large; hence let it be quite understood that these latter may, in a healthy person cause no inconvenience whatever, but if such foods are to serve as a basis of nourishment larger quantities will have to be consumed than of the more digestible foods.

Relative digestibility of rice, bread, and potatoes.

§ 31. Sugar cannot be made the basis of diet, but rice can, so that taking complex foods, rice heads the list. Of the three great foods on which, with very little addition, millions of human beings live—viz., rice, bread, and potatoes—rice is nearly all assimilated, fine wheaten bread being almost equal to rice, while with potatoes, there is nearly 10 per cent. of waste, or substances which pass away without being utilised. So that in point of economy, and considering the relative price of the three, rice stands first, especially in the lands of its culture.

Digestibility of meat.

With the exception of sugar, rice, and fine white bread, all meats, and meaty substances, whether veal, mutton, bacon, or beef, are far easier digested than vegetables; the small absorption of carrots, turnips, cabbages, peas and beans, is due to the amount of cellulose or woody fibre they contain.

Gelatin.

§ 32. Although gelatin in its chemical composition is so nearly allied to the albumenous or meaty class of foods, it will not support life alone; nor will it even replace meat; 50 per cent. of it leaves the body without having ministered to its nourishment; the remaining 50 is supposed to be split up into a urea moiety and a fat moiety; it does not seem capable, like meat, of directly assisting protoplasmic growth, but if given as a part of a mixed diet, it is found that it is in a way a food, for the strength can then be supported on, as it were, a lower nitrogenous level.

DIVISION III.

FLESH AND MILK.

CHAPTER XIII.

MEAT.

§ 33. WHAT meat people eat and what they reject is decided almost entirely by prejudice and custom. There is no consistency in eating rabbits and not rats; enjoying a reptile like the turtle and shuddering at frogs; but appetite is never governed by reason, and therefore no consistency is to be expected.

The English a meat-eating nation.

The English nation probably eats more meat than any of the European peoples; it has been estimated by Schieffersteckar and Mayer that the daily consumption per head of meat in Königsberg may be put at 3·2 ozs., in Munich 6·2 ozs., in Paris 6½ ozs., in London 9·6 ozs.; but surely the latter amount is too high.

General composition of flesh.

§ 34. Ordinary meat consists of fat, water, nitrogenous substances, non-nitrogenous substances, and mineral matters. However carefully the fat is removed from meat, some fat may be extracted by the chemist; flesh from which the fat has been mechanically removed as far as possible has the following general composition:—

Water	76·0 per cent.
Nitrogenous substances . . .	21·5 „ „
Fat	1·5 „ „
Mineral matter.	1·0 „ „

Fat replaces water.

The water in meat varies much according to the condition of the animal, and even in different parts of the same animal; a piece from the neckbone of an ox, yielding 6 per cent. of fat, contained 73½ per cent. of water; while a piece from the shoulder, containing a little over five times the amount (34 per cent.), only yielded 50½ per cent. of

water. So that the housewife in buying fat meat gets more for her money in the way of solid substance than in buying lean meat.

Crystalline extractives of meat.

The nitrogenous substances in meat are partly in the flesh-juice and partly in the muscular fibre. In the flesh-juice are to be found albumen, and minute quantities of a number of bodies of very definite composition known as kreatin, kreatinin, sarkin, xanthin, urea, uric acid and others. All these can be obtained by chemical art in the crystalline condition. The connecting web binding the muscular fibres into bundles is also nitrogenous, and some of it may, by long boiling, be converted into gelatin.

Fat of meat.

The fat of ordinary meat is perfectly neutral; it consists of varying mixtures of olein, palmitin, and stearin; these again consist of glycerine united with oleic, palmitic, and stearic acids respectively. Olein is fluid, palmitin and stearin are solid; a fat like beef fat, somewhat fluid, contains more olein than a solid fat like that of mutton.

Muscle-sugar.

In meat there is also to be found inosite or muscle-sugar in small quantities.

The mineral matters are composed of the phosphates of potash, soda and lime, with small quantities of iron, common salt and magnesia. Of these the salts of potash are much in excess of the other constituents.

Meat is always a little acid, and broth made from meat is likewise acid; the acidity is due to the acid phosphate of potash and to sarko-lactic acid. The following table gives the average quantity of the various constituents of meat, which has been freed as far as practicable from fat.

	Water	75·0 to 77·0 per cent.
Nitrogenous Constituents	Connective tissue	2·0 to 5·0 " "
	Muscular fibre	13·0 to 18·0 " "
	Albumen	·6 to 4·0 " "
	Kreatin	·07 to ·34 " "
	Sarkin	·01 to ·03 " "
	Kreatinin	
	Xanthin	
	Inosic acid	
	Urea	·01 to ·03 " "
	Uric acid	

Nitrogen-free Organic Matters	Fat	·5 to 2·5	per cent.
	Lactic acid		
	Butyric acid		
	Acetic acid		
	Formic acid		
	Inosite		
	Glycogen	·3 to ·5	" "
Mineral Matters	Potash	·40 to ·50	" "
	Soda	·02 to ·08	" "
	Lime	·01 to ·07	" "
	Magnesia	·02 to ·05	" "
	Iron oxyde	·003 to ·01	" "
	Phosphoric acid	·40 to ·50	" "
	Sulphuric acid	·003 to ·04	" "
	Chlorine	·01 to ·07	" "

§ 35. When meat is macerated in cold water, the albumen, the crystalline nitrogenous substances, the nitrogen-free matters, and nearly all the salts, pass into solution; on boiling the watery extract, albumen is precipitated.

Meat extract. The constituents soluble in water are about 6 to 8 per cent. of the flesh or meat. "Meat extract" in its various forms consists of the soluble portions of the meat extracted by water, then evaporated down to a pasty mass.

Differences in the flesh of various animals. § 36. There is a very considerable and appreciable difference in the taste of veal, pork, beef, lamb, &c.; these differences are partly dependent upon minute odorous matters and very largely on the proportions of fat, water, albumenous matters, and the greater or less difficulty in gelatinising the gelatin-yielding tissues. Messrs. Lawes and Gilbert made some elaborate researches on the composition of animals, not taking for analysis special portions, but finely dividing the whole carcase and thus obtaining a fair sample. I will select a few of their analyses as examples of the variations of the main constituents in different animals.

From the following table it is clear that if fat-free muscle is alone considered, we buy more in an equal weight of veal than in beef, and that in an equal weight of fat beef there is more muscle than in lean mutton; and if we subtract the water, considering the water as of no value, then the following will be the order of merit—fat pork, fat

mutton, fat beef, fat lamb, lean mutton, and fat veal; fat pork containing least water, and fat veal most.

PERCENTAGE COMPOSITION OF THE ENTIRE CARCASE OF ANIMALS, THE BONES HAVING BEEN FIRST REMOVED.

	Fat veal.	Fat lamb.	Lean mutton.	Fat mutton.	Fat beef.	Fat pork.
Water	67·0	53·9	62·0	45·1	51·5	38·5
Albumenous matters	15·8	9·7	11·1	9·9	13·1	8·6
Fat	16·3	35·8	25·4	44·5	34·7	52·6
Mineral matters	0·9	·5	1·5	·5	·7	4·3

There is a fraudulent practice prevalent among butchers of injecting their meat with water; it is done by means of a fine tube, and it is wonderful how much the weight of certain joints, especially pork, may in this way be increased, without any very evident alteration in the appearance of the joint.

Lastly, if the amount of fat be considered, it is exactly the inverse of the water, and it may be said generally that the tendency of fattening is to replace water with fat.

Digestibility of meat.

§ 37. The amount of digestibility of meat varies much. Many years ago some careful experiments were made by Dr. Beaumont on a Canadian, who had a fistula or wound leading into his stomach; through this opening different foods could be introduced and withdrawn at pleasure. The following are the various periods of time necessary to dissolve up the "meats" mentioned.

	Time in hours and minutes for the meat to be dissolved. h.	m.
Boiled pigs' feet (soused)	1	0
Boiled tripe	1	0
Broiled venison	1	30
Boiled turkey	2	25
Roasted goose	2	30
Roasted sucking pig	2	30
Broiled lamb	2	30
Fricasseed chicken	2	45
Boiled beef	2	45
Roasted beef	3	0

	Time in hours and minutes for the meat to be dissolved. h.	m.
Boiled mutton	3	0
Roasted mutton	3	15
Fried beef	4	0
Boiled fowls	4	0
Roasted fowls	4	0
Roasted ducks	4	0
Roasted pork	5	15

In this list pigs' feet, tripe and venison, stand at the top of the list, the time required for their disappearance being much less than the remainder. Roast pork in the Canadian's stomach was not fully digested until more than five hours had elapsed. The digestion of various people differs much, so that the time in the table represents this particular Canadian's power of digesting meat, and it does not necessarily follow that every person will be five hours in assimilating roast pork; but the order in which the meats disappear is probably constant with all people. Beaumont's experiments.

There have been some experiments lately by E. Jessen ('Bied. Centr. 1883,' 602–604), in which 100 parts by weight of meat, both in the uncooked and cooked condition, were introduced into the stomach of a healthy man; from time to time a portion of the contents of the stomach were withdrawn by a stomach-pump and examined. The results were as follows:— Jessen's experiments.

	Time in hours required for digestion.
Raw beef	2
Half boiled	2½
Well boiled	3
Half roasted	3
Well roasted	4
Raw mutton	2
Raw veal	2½
Raw pork	3

It is evident from these facts that raw meat is much quicker assimilated than cooked meat.

§ 38. The application of heat coagulates the albumenous matters in the meat, rendering them denser and harder, and Effect of cooking meat.

hence not so easily permeated by the digestive fluids. If we could overcome our prejudices in favour of cooked meat and eat raw, the advantages would be more than counterbalanced by the danger of contracting parasitic and other diseases. Animals are affected with parasites like trichinæ, which, unless killed by cooking, cause a painful and even fatal malady.

Poisonous meat.

Meat is sometimes a poison; the flesh of a healthy animal decomposes and develops a peculiar substance which causes all the symptoms of an irritant poison. Such cases are rather frequent in Germany, as the result of eating sausages. Meat again sometimes plays the part of an infection-carrier; an animal dies of some zymotic disease, and the carcase is put in the market by an unscrupulous butcher; the Welbeck and Nottingham outbreaks, in which altogether nearly ninety people suffered severely, and five died, are examples of this, and were ascribed to eating pork. The pig died possibly from the disease Dr. Klein has called pneumo-enteritis.*

Relation of bone to meat.

§ 39. The relation of bone to meat is one of those practical matters which an intelligent and economical housewife should consider. The butcher calculates, and his calculation is fairly correct, the average weight of the leg bone in a leg of mutton of eight pounds is one pound; the price of a leg of mutton is now about 11½*d.* per lb., and therefore the meat, for we do not eat the bone, is really 13*d.* Similarly the shoulder of seven pounds will generally have a pound of bone, price 10½*d.*, but really 14*d.* per lb. In a sirloin of beef weighing 40 pounds, five of the 40 is bone, and though the apparent price is 10½*d.* its real price is 1*s.* In this way it may similarly be shown that the wing rib of beef, sold at 1*s.* per pound, is really an excessively dear joint, a quarter of it being bone, and the actual price no less than 16*d.* per pound.

It is then often more economical to purchase steak or

* For an account of the sausage poison, and of the Nottingham and Welbeck cases, see the Author's work on 'Poisons,' pp. 474, 475, 477, *et seq.*

portions of the carcase free from bone, the increase of price being more apparent than real.

One pennyworth of meat.

If the bone is deducted from all joints, we shall not be far wrong in putting the general price of all butchers' meat (joints) at 1*s*., one pennyworth of good beef will then be equal to less than 300 grains of water-free solid nutriment thus:—

ONE PENNYWORTH OF GOOD FAT BEEF.

	Grains.
Water	300
Albumenous matters	76
Fat	204
Salts	4
	584, or $1\frac{3}{10}$ oz.

CHAPTER XIV.

FISH.

Two classes of fish, the fat and the lean.

§ 40. The various kinds of edible fish considered as foods may be divided into two classes, fat fish and lean fish. Examples of fat fish are salmon, mackerel, eels and herrings ; examples of lean fish are whiting, cod, haddock, sole, plaice, and flounders. The main difference in their chemical composition is the amount of fat they contain ; if we dissolve out the fat from the salmon by means of a solvent like ether, and operate upon codfish in the same way, the product thus made fat-free is in each case a white flaky, fibrinous substance, in every respect identical ; but the ether solution from the salmon and cod respectively, is in appearance and contents very different.

Composition of salmon.

§ 41. *Fat Fish.*—I made some analyses of cooked and uncooked salmon last year, and will give the general results.

ANALYSES OF SALMON.

	Uncooked. Parts per 100.	Boiled. Parts per 100.
Water	71·50	65·28
Fibrin and albumen	18·75	25·90
Colouring and extractive matter soluble in alcohol	2·95	2·11
Fat	6·22	5·90
Ash	·58	·81
	100·00	100·00

The salmon oil always contains some free acid, and is very difficult to obtain free from the pink colouring matter, which latter seems to be of a remarkably complex composition.

The salmon I purchased at a time when the price had sunk to 13*d.* per lb.; hence a pennyworth was equal to— A pennyworth of salmon.

	Grains.
Water	385
Fibrin and albumen	101
Extractive matters	16
Fat	33
Mineral matter	3
	538, or 1¼ oz.

Salmon then at 13*d.* per lb. does not compare favourably with beef at 1*s.* (See p. 295.) As another example of the fat fish I will give two analyses of mackerel, one in the fresh condition, another in the salted condition. Composition of mackerel.

	Fresh mackerel in 100 parts (Payen).	Salted mackerel in 100 parts (Aug. Almén).
Water	68·27	48·43
Albumenous and fibrinous matters	23·42	20·82
Fat	6·76	14·10
Extractive matters		·38
Salts	1·55	16.27
	100·00	100.00

The price of mackerel varies much at different times of the year, and according to the season, but its average is about 2*d.* per lb.*

One pennyworth at this price compares favourably with butchers' meat, for half a pound would give the following:— One pennyworth of mackerel.

	ozs. and tenths of ozs.
Water	5·5
Albumenous and extractive matters	1·9
Fat	·5
Salts	.1
	8·0 ozs.

* Not that it is sold by the pound, but so much a fish, from 2*d.* to 8*d.*

Composition of codfish.

§ 42. *Lean Fish*, or those which have little fat. No better example of this class can be found than codfish; this fish in the fresh state contains in 100 parts—

Water	77·50
Albumenous matters	18·50
Fat	3.00
Salts	1·00
	100·00

One pennyworth of cod.

The average price of cod sold retail is about 3*d.* per lb.; it is sometimes as low as 2*d.* in London, and rises as high, as 8*d.*; one penny would then generally purchase 5⅓ ozs. which would have the following composition:—

	ozs.
Water	4·13
Albumenous matters	·98
Fat	·16
Salts	·05
	5.32

Here again in respect of economy codfish is far superior to butchers' meat; for the same money more nutriment can be bought, and what is true of cod is also true of all the cheaper white fish—directly the price of any white fish sinks to 2*d.* or 3*d.* a lb., the advantage over the joints of the butcher is evident. There is no more practical way of cheapening food for the hungry classes than by encouraging the fishing industries; facilitating the transit of fish from the coasts inland, establishing markets, and lastly teaching the people how to cook their fish properly.

CHAPTER XV.

TINNED FOODS.

§ 43. A very large industry has sprung up of late years, in the preservation of foods by enclosing them in metal boxes, having first destroyed any putrefactive germs by heat, then hermetically sealing. In this way excluded from the air and from all that air carries, meats and fruits may be sheltered from decay, and the produce of American prairies and tropical forests conveyed to our tables with all their juices and virtues intact. **Tinned meats**

A sample of tinned corned beef analysed by Mr. Wigner gave the following results:—

Water	64·09
Albumenoids	24·44
Fat	6·71
Saline matters	4·76

When it is considered that tinned meat has no bone, that it contains less water, and more fat and albumenoids than fresh meat, it is as an article of nourishment cheaper than ordinary butchers' meat.

§ 44. In nearly every sample of meat and fish preserved in this way, a careful analysis will detect a trace of tin caused by the feebly acid juice of the flesh attacking the tin, but the amount is so small that it can have no injurious effect. **Tin in most tinned meats.**

Apricots, tomatoes, pineapples, cranberries, &c., are also preserved in the same way; and practically the preserved are identical with fresh fruits, save certain delicate and evanescent flavours, which are weakened or lost. In 1883, I examined 23 samples of tinned fruits with the special object of ascertaining the amount of metallic contamination. Each pound tin contained amounts of the dissolved metal from $1\frac{1}{2}$ up to 11 grains. The fruits containing 9, 10 and **Tinned fruits always contain more or less dissolved metal.**

11 grains per lb. of tin were cheap brands of apricots. This then is a great disadvantage, for although two or three grains of a soluble salt of tin in fruit may have no perceptible effect, a larger quantity may cause indigestion, and irritation of the bowels, especially in children, the class most fond of fruit.

At the same time it is only just to observe that some purveyors, by carefully selecting their tins, seeing that they are free from all scratches, and employing fruit with only a moderate acidity, have succeeded in the preservation of fruit, in which the tin contamination is very slight.

CHAPTER XVI.

MILK.*

§ 45. The natural food of all young mammals—whether human-mammal or beast-mammal—is milk. Milk, although a fluid that is for the most part water, yet contains matters which are assimilated readily by the new-born, and on which the young increase in weight, grow, and become fat. Milk from the earliest times, even when its composition was most imperfectly known, has been considered the type of foods. Before the 17th century it was thought to consist of water, cheesy matter, and fat; but in 1619 Bartoletus, in a curious treatise, first mentions what he called the "*Manna*" of milk, and what we call "milk-sugar." This discovery was not known beyond Italy for more than a century. The first to observe the microscopic characters of milk was Leeuwenhoek, who in the early part of the 18th century described it as a fluid containing many globules. Some which he judged to be of a buttery nature rose to the top of the liquid; others again sank to the bottom—these he considered to be of another composition.

Milk the food of the young mammal.

Discovery of milk-sugar.

Microscopical characters of milk.

§ 46. The number of substances which have been found constantly in milk has so much increased during this century, that in my work on Foods (p. 214) I have enumerated, reckoning the fat and the ash as single substances, no less than fifteen constituents. For our purpose, however, we may consider milk to be composed of water, casein, milk-sugar, milk-fat (butter), and mineral substances (ash).

Complexity of milk.

§ 47. The following is the average composition of the milks which are in common use as foods:—

General composition of milk.

* For the composition of buttermilk, cream, cheese, &c., see the tables at the end of this Handbook, pp. 349–354.

—	Cow's milk.	Ass's milk.	Human milk.	Goat's milk.
Water	86·87	91·17	88·00	87·54
Casein and albumen .	4·65	1·79	2·97	3·62
Milk-fat	3·50	1·02	2·90	4·20
Milk-sugar . . .	4·28	5·60	5·97	4·08
Ash	·70	·42	·16	·56

These different constituents are partly in solution, partly in suspension. The substances in solution are albumen, a portion of the casein, milk-sugar, and a portion of the mineral constituents; the remainder of the casein in the form of very fine particles, each particle holding in close union a little mineral matter, and the fat in the form of little globules, are in suspension. The little globules are in number in direct relation to the richness in fat; milk containing 2½ per cent. will contain about 190 million of globules in a millimetre, while milk containing 3 per cent. will have about 270 millions of globules in the same quantity.

Distribution of the components of milk, some in solution, others in suspension.

Specific gravity of milk.

§ 48. If a bottle holding by weight exactly 1000 grains of water, be filled with milk, that bulk of milk will then weigh, if of average good quality, 1032 grains; if the milk is excessively rich in fat it may only weigh 1028, or on the other hand if it is watered the weight may in like manner be decreased. An investigation of this sort is called taking the "*specific gravity.*" In practice it is only occasionally done in this manner. Generally a little float called a lactometer is placed in the milk; as soon as it has displaced a bulk of milk equal to its own weight, there is equilibrium, and the mark on the scale to which it has sunk is read off, giving the gravity. It is then easily understood that the gravity is the result of three things—the amount of fat in a milk which tends to lower the gravity, fat being lighter than water—the amount of water which also tends to lower the gravity to its own standard—and the amount of milk-sugar and the other matters which tend to raise the gravity.

§ 49. All the constituents of a perfect diet are in milk.

The carbohydrates have their representatives in milk-sugar; the meaty or nitrogenous substances have their representatives in casein with albumen; there are also fat, mineral constituents and water. This being so, it might be supposed that milk would be a suitable food for every age and condition of life, and that an adult ought to thrive if fed on a diet wholly composed of milk solids; but this is not the case. As an adjunct to other foods it is useful to the full-grown, but it is essentially a diet for an infant, not for a man. The waste floating down the intestinal canal of an infant fed on milk is about 6 per cent. Rübner, in an experimental feeding of four men with milk, found that from 8 to 10 per cent. of the milk solids passed away without having been assimilated.

All the constituents of a perfect diet represented in milk.

Milk a food for children, not for adults.

§ 50. I have attempted to calculate the relative value of the water-free solids in a quart of milk, on the following principles.

The first thing is to translate a measure of milk, e.g., a quart into weight. The weight will vary as the "specific gravity." A quart of milk of the specific gravity corresponding to the composition given at p. 302, will weigh 18080 grains or 41·3 ozs. avoirdupois containing—

	ozs.
Milk solids, minus fat	4·0
Milk-fat	1·4
Water	35·9
	41·3

There are varying prices for milk, but to the London public we may consider it to average 4*d.* per quart; the market price of milk-fat when made into butter can be shown to be 3·36*d.* for 1000 grains; it hence follows that the 1·4 oz. of milk-fat will have a value of $2\frac{1}{10}d.$ and the fat free solids must be equal to $1\frac{9}{10}d.$

Price of milk and value of its constituents.

Hence if this reasoning be correct, 1000 grains of fat-free solids equal 1·09*d.*

1000 grains of milk-fat equal 3·36*d.*, and further for 1*d.* we get in good milk about an ounce of fat-free solids

and about $\frac{3}{10}$ths of an ounce of milk-fat, which $\frac{3}{10}$ths of an ounce should correspond to an ounce of cream.

Milk then, in London, even if it were a suitable diet for the adult would be a very dear one.

Adulteration of milk.

§ 51. The scope of this little treatise does not take in adulteration, but it may be useful, on account of the prevalence of the fraud, to explain the principles on which it is detected, and on which the amount of adulteration is calculated.

Analysis of milk.

The analyst takes a carefully weighed or measured quantity of the milk and places it in a little dish the weight of which is known; the dish with its contents is then submitted to a steam-heat which dries the milk up, that is, expels the water; when dry the weight is again taken, and the loss reckoned as water, the residue being technically called the *total milk solids*; these solids are soaked in ether, which dissolves out the fat, and the solids now fat-free after expelling any trace of ether by a short exposure to a gentle heat, are again weighed; the loss is the "fat," the remaining substances on the dish being technically called *the solids not fat*; these are now burnt and a little grey ash is left, this is the mineral matter and returned as such, or it is called the "ash." The most important factor for determining watering of milk is the "solids not fat," which in milk derived from a healthy cow have not been observed to fall below 9 per cent.; hence this number is adopted by the Society of Analysts as a standard. A milk with the solids falling below 9 per cent. would in the ordinary way be returned as adulterated except the amount of fat in the milk was so great as to bring the milk up to the quality of a fair milk. The amount of adulteration is ascertained by a rule of three sum. For example, if the analyst found 8 per cent. of solids not fat in a milk, he would multiply 8 by 100 and divide by 9, which gives 88·8 as the amount of real milk in the 100; he might then certify that the milk was adulterated to the extent of *at least* 11·2 per cent. It must be perfectly understood that no analyst ever pretends to

How the water in milk is detected.

certify the exact amount of adulteration, for the composition of milk varies within certain limits ; all that he can do is to work by a standard and certify to that standard.

From my own analyses year by year, I have calculated that even in St. Marylebone—a parish in which the Sale of Food and Drugs Act is in systematic operation—there is yet a loss to the inhabitants of at least £10,000 a year from the adulteration of milk.

Money loss by the prevalence of adulteration.

CHAPTER XVII.

BUTTER.

The process of butter-making.

§ 52. The little globules of fat floating in milk are quite isolated one from another, and it has long been a disputed point whether some thin membrane does not surround each globule ; that is, each little round sphere that we see by the microscope is supposed to possess, egg-like, an excessively thin shell, which has to be broken before two globules of fat unite. The number of scientific papers both for and against this view is considerable, but the point to us is immaterial ; the fact remains that if milk is allowed to rest quiet, some considerable portion of the fat rises in the shape of cream,* but that however rich and dense the cream may be, it can never be made into butter without considerable agitation. Another condition necessary to ensure the formation of butter is that the cream must be feebly acid.

Butter-fat is never pure fat.

§ 53. However carefully the lumps of butter-fat are separated from the liquid in which they float, and however strongly they are pressed, as might be expected, some of the other constituents remain. We find all butter to retain mechanically water, casein, and with the casein a little mineral matter ; the water of the butter also contains a little lactic acid derived from the milk-sugar, and traces of other constituents. Salt is added to butter to preserve it ; the quantity of the salt added makes the difference between salt and fresh butter ; fresh butter contains but a little salt ; salt butter much salt.

Difference between salt and fresh butter.

If a small quantity of butter is melted in a graduated

* The old-fashioned way of allowing the cream to rise is in large establishments almost universally superseded by a method of separating the cream by centrifugal machines. These machines may be seen in operation at the model dairies in the exhibition.

tube, the water separates and the butter-fat rises to the top, the curd (casein) sinking to the bottom. In this way a rough proximate analysis may be made. The chemist operates in a different way, and pretty much on the same lines as in the analysis of milk (see page 324), drying up the water, dissolving out the fat by solvents, lastly destroying all that will burn by fire, and by a cremation in miniature arriving at the amount of "ash." How the composition of butter is known.

§ 54. Last year I investigated the butter supply of the parish of St. Marylebone, and ascertained the usual composition of pure butter, sold during the March quarter of that year at 16*d.* per lb., to be as follows:—

—	Per cent.	Ozs. and tenths of an oz. in a lb.
Butter-fat (sp. gr. ·9121)	84·3	13·5
Salt	1·3	·2
Curd	2·3	·4
Water	12·1	1·9
	100·0	16·0

The mean composition of butter sold at 18*d.* was as follows:—

—	Per cent.	Ozs. and tenths of an oz. in a lb.
Butter-fat (sp. gr. ·9118)	84·2	13·5
Salt	1·0	·2
Curd	2·4	·4
Water	12·4	1·9
	100·0	16·0

Since, when we buy butter our sole object is to buy the fat; the water, curd and salt is of no value, and considered in this way the actual price of the butter-fat in the 16*d.* butter was 18¾*d.* per lb., while in the 18*d.* butter it was 21¼*d.* The difference of price in these two classes of butter was neither supported by analysis nor by taste, and generally Price and real value of butter.

speaking the price of butter is governed by no settled principle.

Composition of butter-fat.

§ 55. The butter-fat looks a simple single substance, but this is not the case. It is a mixture of at least seven fats, each of the seven again being composed of a fatty acid united with glycerin; besides this the butter is coloured by a small quantity of a colouring matter of complex composition. The amounts in 100 parts of butter-fat are as follows:—

Glycerides:			
Olein	42·21,	equal to oleic acid	40·40
Stearin, Palmitin	50·00,	equal to stearic and palmitic acids	47·50
Butyrin	7·69,	butyric acid	6·72
Caproin, Caprylin, Rutin	.10		

Separation of fatty acids and glycerin.

By dissolving the butter-fat in a solution of potash in spirit, and heating, the olein, stearin, &c., are broken up into their respective fatty acids and glycerin, the fatty acid at once combining with the potash to form "a soap;" but on adding a strong mineral acid to the soap, the fatty acids are set free, and on driving off the spirit the acids may then be separated into two classes, one class soluble in water, and the other insoluble; the soluble acids being butyric acids with small quantities of caproic, caprylic and rutic, while the oleic, stearic and palmitic acids are insoluble in water. It is in the relatively large amounts of glycerides yielding soluble fatty acids, from five to seven per cent., that butter differs from animal fats and from artificial butter or oleomargarin. For instance, the fat of butterine has the following average composition:—

Two classes of fatty acids, one soluble, the other insoluble.

Palmitin	22.3
Stearin	46·9
Olein	30·4
Butyrin, &c.	·4

Hence one of the most important processes in the analysis of butter-fat is the careful determination of the relative proportion of the soluble and insoluble fatty acids.

Of all fats butter-fat seems to be the most easily assimilated: persons who are unable to eat a sufficient quantity of other animal fats, can always eat and enjoy butter. Nevertheless it is entirely an open question whether there is any difference of nutritive value between equal weights of carbon in butter-fat, beef-fat or mutton-fat.

Easy digestibility of butter-fat.

DIVISION IV.

CHIEF SOURCES OF THE CARBOHYDRATES.

CHAPTER XVIII.

BREAD—FLOUR.

Definition of bread.

§ 56. BREAD is a term applied to any form of flour made into a paste with water, permeated by the gases of fermentation, and baked. Thus we may have bread made from wheat, from rye, or from any other cereal.

Structure of the wheat grain.

If a grain of wheat be taken, divided in half, and then an extremely thin transparent section cut, the following structures will be seen (see Fig. 1).* First, on the outside some

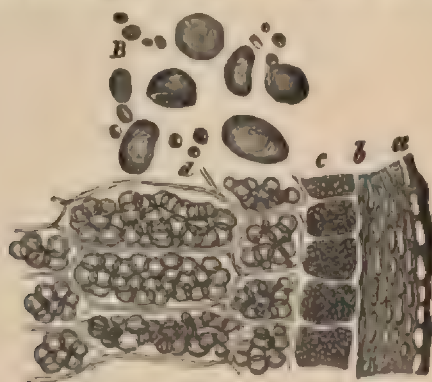


FIG. 1.—SECTION OF A GRAIN OF WHEAT.

thick walled cells (*a*) closely applied to others flatter and more compressed (*b*); these together make the bran and cuticle. Within these again are some larger and darker, almost square spaces, filled with a granular substance (*c*),

* This figure is from the Author's work on 'Foods, their Composition and Analysis.'

these are called the gluten cells, while the bulk of the wheat grain is made up of (*d*) the starch cells, which are largish spaces, crammed and packed with starch granules. The object of grinding the wheat grain to flour is not alone to divide it finely, but to get rid of the layers *a* and *b*. The differences between the different varieties of flour are chiefly dependent upon the fineness of the flour, the completeness with which the bran and cuticle have been separated, the purity and healthiness of the wheat, and also the kind of wheat used.

§ 57. The composition of wheat is very complex; the meaty or nitrogenous substances are represented by gluten and vegetable albumen; and the carbohydrates by fat and starch. **Composition of wheat.**

The "whole meal" from which nothing has been separated contains the following :—

			In 100 parts.
Water			14·0
Nitrogenous substances, part of which is gluten, but a large proportion of which cannot serve for nutrition			21·8
Carbohydrates	Fat	1·2	60·9
	Starch	59·7	
Woody fibre (cellulose)			1·7
Mineral matters			1·6

The white flour from which the bran has been separated has the following composition :— **Composition of flour.**

			In 100 parts.
Water			16·5
Gluten and other nitrogenous bodies			8·59
Nitrogenous substances not of the nature of albumen			3·41
Carbohydrates	Fat	1·2	70·8
	Starch	69·6	
Mineral matters			·7

The gluten may be readily separated from the starchy matter by making flour up into a paste, and then washing the mass for a long time with a thin stream of water, until the water flowing away is no longer milky. It is thus obtained as a yellowish grey elastic, adhesive mass, drying

up into a horny, brittle substance; it is of very complicated composition.*

Changes taking place in bread-making.

§ 58. The changes which take place in the process of bread-making are as follows. On making the flour into a paste and the addition of yeast, if the dough is placed in a warm place, fermentation commences just as in the brewing of beer, the starch to a certain extent is converted into sugar, the sugar is decomposed into alcohol and carbonic acid gas; the latter would if evolved in a fluid escape, but the tenacious gluten holds it imprisoned, and the little cavities in light bread are the remnants of centres of considerable activity, each marking the site of a group of yeast-cells, which, during fermentation, were budding, growing, multiplying, changing starch into sugar, and sugar into gas and alcohol, the gas expanding the dough into, as it were, bubbles.

Tracing the chemical changes, the nitrogenous matters partly become less soluble, and in the crust they are to some extent destroyed.

The carbohydrates, on the other hand, become more soluble, for the starch granules are either broken up or quite changed, some part being converted into sugar and some into dextrin; the sugar may be further decomposed in two ways, viz. into alcohol, and into lactic acid. The alcohol nearly all escapes, but a portion of it remains and a portion is oxidised into acetic acid. With the growth of chemical knowledge, it began to be clearly understood that the object of fermentation was simply to ferment the dough with gas, to make it in structure like a sponge;

Artificial aëration of bread.

processes were then suggested by which carbonic acid gas was developed *in situ*, not as a result of the breath, as it were, of living cells, but evolved from purely mineral substances. Liebig proposed the addition in suitable proportions of biphosphate of lime, bicarbonate of soda, and chloride of potassium, to the flour; on adding water to make a dough, and warming, a gentle continuous evolution of gas

* See the Author's work on 'Foods, their Composition and Analysis,' p. 150.

takes place, very similar in its regularity to that of ordinary fermentation, and in this way a good light bread may be made. The different "baking powders" are all mixtures of substances which, on the addition of water, enter into chemical reaction and evolve carbonic acid gas. A very scientific method of making bread was some years ago patented by Dr. Dauglish. Instead of the addition of any solid substance to the flour, the water used for making the bread is saturated with carbonic acid gas. The mixing and manufacture is all done by machinery; hence this process has the merit of great purity and cleanliness.

The acid re-action of bread. § 59. Bread made in dirty places, or in itself damaged, may have various acids developed, especially butyric, and then smells peculiarly offensive.

All bread is, however, acid in a feeble degree, and if it is soaked in water, and the water tested with blue litmus, the litmus will be reddened.

Alcohol in bread. The mean amount of alcohol in fresh bread is ·313 per cent.; that is, a pound loaf would yield, if very carefully distilled, about twenty-two grains (considerably less than a teaspoonful). As the bread gets staler, the quantity decreases.

Stale bread. The changes taking place when bread becomes "stale" are but little understood, but certainly the seat of change is the gluten, and not the carbohydrate. The bread feels dryer and harder, and is no longer doughy. On re-baking, the bread becomes apparently new again; but this re-juvenescence, as it were, cannot be repeated often. At each re-baking there is a loss of water, and when 30 per cent. of water has been lost, re-baking fails to cause any change.

Digestibility of bread. § 60. Bread of fine wheaten flour is, according to various well-arranged experiments, more digestible than meat, that is, it leaves less residue; on the other hand, rye bread and brown bread are much inferior in digestibility.

Whole-meal bread. Bread made of whole meal will show to analysis a much higher content of nitrogenous substances, but the nitrogen is that of the bran and cuticle, and is in a form not to be

assimilated. Hence we find that whereas with wheaten bread only five per cent. passes away to waste, the bread in which the bran and cuticle are more or less retained, gives double the amount of waste.

The general composition of fine bread and coarse bread is as follows :—

—		Fine bread.		Coarse bread.
Water		38·51		41·02
Nitrogenous substances .		6·82		6·23
Fat.		·77		·22
Carbohydrates { Sugar	2·37		2·13	
Carbohydrates { Starch, Dextrin	49·97	52·34	48·69	50·82
Woody fibre . . .		·38		·62
Mineral matters . .		1·18		1·09

Alum in bread.

§ 61. There is little adulteration of bread save with alum. The long and formidable list of substances supposed to be used by fraudulent bakers, such as sulphate of copper, peas, beans, &c., are drawn from rare instances, or from times of famine, or are based upon theory rather than observation. Bakers' bread in this country, taking it as a whole, is of fair purity, and is wholesome. Where the customer is cheated is mainly in the weight ; here there are really serious and continuous frauds. Notwithstanding Inspectors of Weights and Measures, such frauds are practically unchecked, and only limited by the prudential conscience of the baker.

Detection of alum in bread.

I devised some two years ago a very ready method of detecting alum in bread by a simple test, and one which takes no skill in its application. The materials required for the test are a solution or tincture of logwood to which a sufficient quantity of carbonate of ammonia has been added to render it strongly alkaline, and some slips of gelatin ; a slice of the bread is then crumbled into a glass, and covered with pure water, a slip of gelatin is added, and the whole allowed to stand over night. In the morning the

masses; these are represented more highly magnified at *B*. The oat has a much higher content of fat than any other common cereal (except maize); the fat or oil is not a perfectly neutral oil, but contains some free fatty acid.

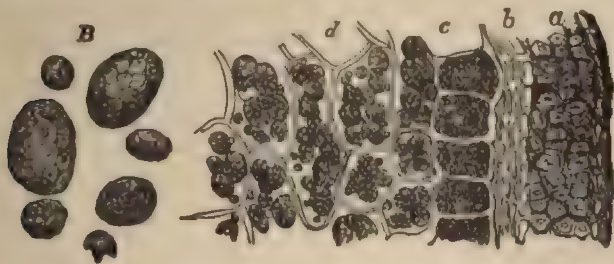


FIG. 2.—SECTION OF THE OAT GRAIN.

Weight for weight, oatmeal has been stated to be more nutritious than wheat meal or flour, but in reality there is not much difference between them, when a proper distinction is drawn between the nitrogenous matters available for the purposes of nutriment, and substances which contain nitrogen, but which pass away through the alimentary canal without serving any useful purpose.

Flour and oatmeal compared both as to price and nutrient value.

§ 64. Oatmeal is cheaper than the better kind of flour known as *best whites*, but about the same price as the common flour, that is when bought retail; both average 2*d*. per lb., hence 1*d*. will buy the following amounts of principles in flour and oatmeal; the figures represent ounces and tenths of ounces.*

—	Flour.	Oatmeal.
	ozs.	ozs.
Albumenoids	·7	·8
Fat	·1	·5
Carbohydrates	5·5	4·4
	6·3	5·7

* I have omitted the mineral matter, water, and non-assimilable nitrogenous matter, and added the real nutritive substances up as above.

From this table it will be evident that a pennyworth of flour buys 6·3 ozs. of nourishing material while a pennyworth of oatmeal buys 5·7 ozs.*

—	Constituents in ½ lb. (3500 grains) of flour bought for one penny.	Constituents in ½ lb. (3500 grains) of oatmeal bought for one penny.
	ozs.	ozs.
Water	1·3	1·0
Gluten and other nitrogenous substances which may be digested	·7	·8
Nitrogenous substances which will not be digested	·3	·2
Fat	·1	·5
Carbohydrates	5·55	4·4
Woody fibre		·9
Mineral matter	·05	·2
	½ lb. or 8·00	½ lb. 8·00

On the other hand, the comparatively large proportion of fat in the oat renders it a better balanced food than flour; a person could live with more comfort on oatmeal alone than on flour alone. Oatmeal cannot be made into light bread, it is therefore when baked converted into cakes. Its most popular form is that of porridge, in which the ground meal is well softened by boiling, and made more palatable by a little salt and milk. The decorticated oatmeal, when crushed, goes by the name of groats, and is used for making gruel. It is a curious fact that at the latter end of the 17th century, gruel was a favourite drink asked for by the public in the London taverns.

In England, porridge, gruel, and "black puddings" are the only common forms into which oatmeal is made; but in Scotland, in Norway, and Sweden, there are a great variety of oatmeal cakes and dishes.

Components of barley.

§ 65. *Barley.*—Barley ground into meal and made into a close bread, was so late as the time of Charles I. used very extensively in England, and to a great extent took the

* I have omitted the mineral matter, water, and non-assimilable nitrogenous matter, and added the real nutritive substances up as above.

place of wheaten bread; its percentage composition is as follows:—

Water	15·06
Digestible nitrogenous substances	9·79
Indigestible " "	1·96
Fat	1·71
Carbohydrates	70·90
Woody fibre	·11
Mineral matter	·47
	100·00

Barley meal is about 1*d.* per pound, and subtracting all matters not available for nourishment, it would seem that for this small sum, about 13 ounces of dry barley meal nutriment, or twice the amount of food in flour, and four times that of oatmeal, can be bought.

Therefore barley meal is an extremely cheap food; perhaps the cheapest. Barley meal cannot be made into light bread, for its gluten is deficient, but when mixed with flour, the combination answers very well, and it can be then manufactured into palatable, somewhat close bread.

Pearl barley and Scotch barley, so much used to give consistence to broth, are simply the grain deprived of its outer covering and then rounded by attrition.

Components of rye meal.

§ 66. *Rye meal*, once an article of common diet in this country, and the basis of the dark sour breads of Northern Europe and Holland, is of very nearly the same composition chemically as barley meal.

The rye becomes attacked with a peculiar fungus, which has powerful medicinal properties; when rye thus affected is made up into bread, it causes a very extraordinary disease known as

Ergotism.

§ 67. *Ergotism*; in this disease mortification of the limbs may take place.* The general disuse of rye bread in England has practically extinguished the disease; but cases on the Continent still occur.

* The various epidemics of ergotism, the varieties of the disease, and the unique Waltisham case, in which, out of a family of eight, seven lost one or more limbs, are fully detailed in the Author's work on Poisons, p. 430, *et seq.*

CHAPTER XX.

MAIZE OR INDIAN CORN.

Structure of maize.

§ 68. Indian corn or maize (*Zea Mayo*) is a native of tropical America, but is cultivated in the south of Europe and in Africa. A section of the seed as seen under the microscope is represented in Fig. 3; *a* is the cellular layer of

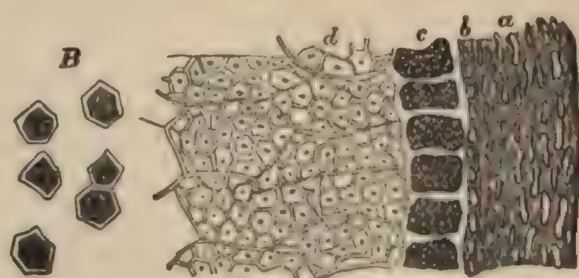


FIG. 3.—SECTION OF INDIAN CORN.

the outer husk, *b* the inner; *c* is the gluten cells, and *d* the curiously shaped starch cells. In many parts of the world maize is the almost exclusive food; in Mexico, where it grows wild, and the Northern States of America, the natives pretty well live upon it.

It cannot be made into light bread.

Indian meal is not capable of being made into a light bread; its proper use is in the form of cakes or puddings or a porridge.

In Ireland it has been much consumed since the potato famine of 1846.

The preparations of Indian meal, like "Polson's patent flour," have been purified from the bitter principle, and are of course much more expensive and palatable than the simply ground meal. The composition of Indian meal is as follows:—

COMPOSITION OF MAIZE IN 100 PARTS.

Water		17·10
Nutritive nitrogenous matters		10·91
Non-nutritive nitrogenous matters		1·89
Oil or fat		7·00†
Carbohydrates	Dextrin and Sugar 1·5	60·50
	Starch 59·0	
Cellulose		1·50
Mineral matter (ash)		1·10
		100·00

The oil or fat which may be extracted from maize is not built up like the animal fats, differing from them in containing free fatty acids; in this respect it agrees with the oily matters derived from the oat and from rye. **The oil.**

§ 69. The finely ground meal may be bought for 1*d.* per lb.; hence calculated in the usual way, one pennyworth would contain the following amounts of real nutriment:— **The money value of maize.**

	ozs.
Nutritive nitrogenous matters	1·7
Fat	1·1
Carbohydrates	9·7
	12½

3 lbs. of the meal would give a diet equal to

	ozs.
Nutritive nitrogenous substances	5·1
Fat	3·3
Carbohydrates	28·8
	37·2

This would be equivalent to 7921 grains of carbon and 351 grains of nitrogen, just about the amount which would keep up the strength of an active labourer in full work.

Unfortunately its bitter taste is a bar to the food becoming so popular as to entirely supplant the dearer cereals. **The bitter taste of maize.**

A disease in Italy has been ascribed to the long-continued use of maize as a food, but it is not certain whether it is not rather due to a fungus attacking the maize, than to the use of pure maize.

* The maize oil or fat in some samples sinks as low as 3 per cent., in others it may rise to 9 per cent.

CHAPTER XXI.

RICE.

Composition of rice.

§ 70. More than a hundred million people in India, China, Egypt, Arabia, and in portions of South America, derive their main food from rice. Amongst ourselves rice is but an adjunct to other foods; the labourer, the artisan, and even the middle class take it only at intervals, and it certainly does not as a rule form part of the daily diet. Rice is obtained from the *Oryza sativa.* Its composition is as follows:—

Water	14·41
Nitrogenous substances	6·94
Fat	·51
Starch	77·61
Woody fibre	·08
Ash	·45
	100·00

Money value of rice.

§ 71. Ground rice is sold at *2d.* per lb.; hence, throwing out the water, the woody fibre, and the mineral matter, we buy half a pound of rice for one penny, and the pennyworth contains—

	ozs.
Nitrogenous substances	·55
Fat	·04
Starch	6·21
	6·8

That is, 6$\frac{4}{5}$ ozs. or nearly 7 ozs. It is thus cheaper than wheat flour, but the great deficiency of rice in fat renders it alone a very unsuitable diet for a temperate or a cold climate. The fat or oil which may be obtained from rice is, like the oils from the cereals, generally acid, from a small quantity of free fatty acid.

CHAPTER XXII.

THE POTATO.

§ 72. The composition of the uncooked potato according to the mean of 70 analyses is as follows :— **Composition.**

	per cent.
Water	75·77
Nutritive nitrogenous substances	·84
Non-nutritive nitrogenous substances	·95
Fatty matter	·16
Starch	20·56
Woody fibre	·75
Ash	·97
	100·00

The average retail price of potatoes being in London about 7 lbs. for *6d.* a single lb. would cost 1*d.*, and would contain the following amounts of real nutriment :— **Money value.**

	grains.
Nutritive nitrogenous substances	58·8
Fat	1·6
Starch	1439·2
	1499·6

That is, about 3⅜ ozs.; hence in buying potatoes in London you get a little more for your money in the way of nourishment than in the purchase of oatmeal, but less than in the purchase of flour. But in the country, the cottager, growing his own potatoes, will raise seven pounds for a penny; under these circumstances it becomes the cheapest vegetable diet obtainable.

§ 73. The potato is mainly composed of starch, but there are other constituents in minute quantity classed under the head of the non-nutritive nitrogenous substances, such as asparagin, an alkaloid called solanine and amido-acids. **Details of the composition of potatoes.**

There are also organic acids such as citric (the acid of the lemon) and succinic acids.

Solanine.

The alkaloid solanine* is very poisonous; it abounds in the plant itself. There are small quantities to be found in potato-peelings but scarcely any in the starchy interior of the potato. Solanine is readily destroyed by a dry heat, so that a baked potato will contain none; similarly boiling potatoes in their "skins" probably extracts the alkaloid.

Antiscorbutic properties of the potato.

In the year 1781, in Sir Gilbert Blane's work entitled 'Diseases of the Fleet,' occurs the first definite statement of the antiscorbutic properties of the potato; properties the existence of which have now from long and varied experience received ample confirmation. Whether these properties are due to the small quantities of citric and organic acids, or to some other constituent, is not at present fully known.

The potato disease.

§ 74. The disease known as the potato disease is caused by a fungus or mould, the history of which has only of late years been fully mastered. This mould has three methods† of reproduction, the most certain of which is by the development of what are called *oospores*, little dark-brown reticulated bodies which are so constructed that they are able to resist the frosts of winter and are very difficult to destroy.

§ 75. If potatoes are supplemented with a little fat, or still better with fat meat such as bacon, they will support life and maintain health for an indefinite time. Such a diet in places where, as in Ireland, both the potatoes are grown and the pig fed by the consumer, is perhaps the cheapest diet possible.

Cheap diet for a labourer.

Half a pound of bacon and 5 lbs. of potatoes would be a daily diet on which a labourer could do hard work and live in good health. It would contain the following water-free constituents:—

* See the Author's work on Poisons, p. 368, *et seq.*

† Fully described and figured in the Author's work on Foods, p. 183.

	ozs.	Nitrogen grains.	carbon. grains.
Albumenoids	8·8 =	607	2050
Fat	3·0 =		1037
Carbohydrates	16·4 =		3184
Salts (mineral matter)	1·0		
		607	6271

The money value of such a diet in London would be perhaps about 9*d.* a day.

Potatoes require some little care in cooking. In a well cooked potato the starch granules are all swollen, distorted, and for the most part ruptured, but in a badly cooked potato this action on the starch granules is only partial, and the potato, instead of having a mealy appearance, is sodden and heavy. **Cooking potatoes.**

When the potato was first introduced into England, its popularity as a diet was slow until people had learned the proper method of cooking it.

DIVISION V.

LEGUMINOUS VEGETABLES—SUCCULENT VEGETABLES AND FRUITS.

CHAPTER XXIII.

LEGUMINOUS VEGETABLES.—PEAS—BEANS—LENTILS.

§ 76. THE ordinary peas, beans, and lentils are members of a well-marked order of plants, distinguished by having flowers with some resemblance to a butterfly, and hence called papilionaceous. No botanical order exists in which there are so many foods and poisons, but the poisons predominate, for as a rule leguminous plants are noxious.

Legumin—vegetable meat.

Those that are edible are distinguished from other members of the vegetable kingdom by containing a nitrogenous principle which has been named Legumin. It is composed of carbon, hydrogen, nitrogen and sulphur, and is of very complex composition ; it may be likened to animal fibrin, or if the expression be permitted it might be called "vegetable meat." The following table gives the relative proportions of the chief constituents in beans, peas and lentils.

COMPOSITION OF BEANS, PEAS, AND LENTILS, IN PARTS PER 100 AND OZS. PER LB.

—	Peas.		Broad Beans.		Kidney Beans.		Lentils.	
	per cent.	per lb.	per cent.	per lb.	per cent.	per lb.	per cent.	per lb.
		ozs.		ozs.		ozs.		ozs.
Water . . .	14·31	2·3	14.84	2·4	13·60	2·2	12·51	2·0
Nutritive nitrogenous substances	19·98	3·2	21·30	3·4	20·81	3·3	22·31	3·6
Non-nutritive nitrogenous substances	2·65	·4	2·36	·4	2.31	·4	2·50	·4
Fat	1·72	·3	1·63	·2	2·28	·3	1·85	·3
Carbohydrates	53·24	8·5	49·25	7·9	53·63	8·6	54·78	8·7
Woody fibre .	5·45	·9	7·47	1·2	3·84	·6	3·58	·6
Ash . . .	2·65	·4	3·15	·5	3·53	·6	2·47	·4
	100·00	16·0	100·00	16·0	100·0	16·0	100·00	16·0

It will then be seen that in the dried state the nutritive value of the various legumes are not widely different.

§ 77. The price of split peas averages $1\frac{1}{2}d.$ a lb. In the pound there are 12 ozs. of nutriment; hence it follows that one pennyworth of peas contains no less than half a pound of nitrogenous and starchy substances capable of being assimilated. **The price of peas.**

§ 78. To utilise the leguminous foods to the best advantage they require to be finely ground into meal and to be thoroughly cooked. An experiment of A. Strümpell bears on this. Leguminous meal was made into cakes, with suitable mixtures of eggs, butter and milk, and eaten, and compared with the result of eating the same substance, without grinding but first soaking in water and then boiling. In the first case 91·8 per cent. of the nitrogen was absorbed, but in the second only 59·8, so that more than half of the "vegetable meat" was wasted. **Legumes must be skilfully prepared and cooked.**

The leguminous seeds, however skilfully prepared, are not palatable alone, they require the addition of certain other things, especially of fat, and it will be noticed on referring to the table that peas and beans are weak in fat; hence the union of bacon with beans, and butter with peas, is founded upon a rational instinct. **Peas and beans, &c., require the addition of animal fats.**

The composition of green peas and beans will be found in the tables at the end of the volume. As might be expected, they are more watery, more palatable, and easier cooked and digested than when dried.

§ 79. They are also capable of being preserved in sealed tins or bottles. It has been the practice to boil the peas previous to their being preserved in copper vessels, and thus impart a fine green colour; in this way some considerable metallic contamination of the vegetable has resulted. There is a patented process by which chlorophyll, the innocent and beautiful green of the plant world, can be separated and applied to heighten the hue of preserved vegetables, and it is to be hoped this method will supplant the coppering process, which may be deleterious. **Preserved peas, and their contamination by metals.**

I have also found tin and lead in preserved peas; the latter in a very beautiful French brand.

German pea-tablets.

§ 80. In Germany there is a condensed food made up of dried and powdered meat incorporated with pea meal by strong pressure. It deserves notice, as one of the most successful examples of a condensed food. The form of the food is that of tablets; its general analysis is as follows:—

	Per cent.
Water	12·09
Nitrogenous matters	31·18
Fat	3·08
Carbohydrates	47·50
Ash	6·15

Of such a food about 2 lbs. daily would support a man in hard work.

Poisonous decomposition of peas.

Peas when preserved in tins hermetically sealed, occasionally undergo some very peculiar decomposition and become poisonous; it would seem that a poison is developed from some change in the legumin analogous to the formation of the cadaveric alkaloids.

CHAPTER XXIV.

SUCCULENT FRUITS AND VEGETABLES.

§ 81. The succulent fruits and vegetables contain so much water that certain animals, such as the rabbit, supplied with "green stuff," never require other water than that taken in the juices of the fresh herb. **The large amount of water in vegetables and fruits.**

The importance of cabbages, carrots, turnips, of apples, pears, raspberries and strawberries, is far more than their nutritive value; for without the addition of these substances, even while eating fresh meat, we are liable to decline in health and suffer from eruptions, while if we eat salt meat for any time, and consume neither potatoes, nor vegetables, nor fruits, then that terrible disease scurvy is imminent.

Prevention of scurvy. The reason why fresh fruits and vegetables prevent and cure scurvy is at present not known with certainty, although so much has been written about it. The supposition is that the organic acids present in vegetables and abounding in fruits, such as malic acid, citric acid, and tartaric acid, are the agencies which produce this beneficial result.

The composition in general terms of most of the succulent fruits and vegetables are to be found in the tables at the end of the volume.

DIVISION VI.

ALKALOID HOLDING DRINKS.

CHAPTER XXV.

TEA, COFFEE, COCOA, AND CHOCOLATE.

The universal craving for the theine holding plants.

§ 82. THERE are certain leaves and berries which, when infused in hot water, impart whatever virtues they possess to the liquid and make a drink—a drink which no tribe of men, once tasting, ever forget. The precious plants grow and thrive, in limited spots of the warmer portions of the earth, from whence their products are exported to every clime, to be consumed by races of every colour.

§ 83. However different in appearance and taste tea, coffee and cocoa may be, there is considerable agreement in their chemical composition and physiological effects; for three special active matters—a crystalline alkaloid, an astringent substance, and a volatile oil—are present in all.

But little nourishment in tea and coffee, but cocoa more of a food.

There is very little nourishment in the ordinary quantities of tea, and coffee, but these drinks give in some obscure way energy to brain and nerve—a stimulus distinguished from that of alcohol, in being not alone different in kind but also in not being followed by a depression.

In cocoa there is more nutriment, and it may be considered as a drink or a food, or as a combination.

Excessive use of tea injurious to some people.

§ 84. There is a moderate and an immoderate use of all things. Certain people acquire a habit of drinking enormous quantities of tea or coffee; the majority, like smokers of tobacco, are not perceptibly affected by this habit; but a

few fall into a dyspeptic nervous state, evidently due to excessive tea-drinking.

Tea better with "starchy" food than "meaty."

Tea and coffee suit "bread and butter meals" rather than meals in which meat is the chief dish; this is thought to be due to the very insoluble compound which the astringent matters in the tea form with albumen.

Varieties of tea.

§ 85. Tea is the dried leaf of different species of *Thea*, a section of the genus *Camellia*; the botanical varieties are not numerous. The tea plants in China, *Thea Bohea*, *T. viridis*, *T. vinensis*, are but varieties of one plant; but the *Thea Assamica*, indigenous in Assam, is possibly a distinct species.

Formerly all our tea was obtained from China. Pepys, a little after its introduction into England, alluded to it as "the Chinese drink," but India year by year cultivates more tea, and it seems likely that she will to a great extent supplant China in the export trade of tea, as far as this country is concerned. In 1871, India's share in feeding us with tea was 11 per cent. of the whole; China's share 89; but in 1881, India's exported tea had grown to 30, China's tea exports had decreased to 70 per cent. of the whole.

Varieties of tea.

The commercial varieties of tea imported into this country are extremely numerous, but seldom does any one of them reach the consumer unmixed; for the wholesale tea merchants carefully improve their teas by "blending." The most common sorts are :—Gunpowder, Hyson, Congou, Caper and Indian tea. Of these, the Gunpowder and Hyson are dried at a higher temperature than the others, and contain therefore less moisture. The Caper may be generally told by the leaves being rolled up into little lumps with starch or gum; as a class they are much adulterated, and in fact can hardly be called genuine tea. Besides these, there are a number of special teas, some of a very high price, and imported in a state of great purity; but such teas are used almost entirely for mixing or blending; they are known under the names of Moyone and Moyone gunpowder, Oolong, Mannuna Kaisou, scented Pekoes, Indian Souchong,

Assam, Java, &c. The names by which teas of commerce are most familiar to the public are simply "green" and "black," which differ merely in accordance with the method of preparation followed. Green tea is prepared from young leaves, which are roasted over a wood fire within an hour or two after being gathered; the black tea leaves, on the other hand, are allowed to lie in heaps, for ten or twelve hours after they have been plucked, during which time they undergo a sort of fermentation; the leaves then pass through certain processes and are slowly dried over charcoal fires.

Black and green tea.

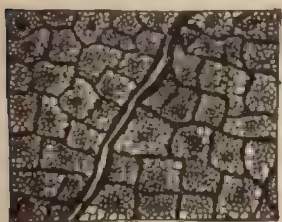
The tea leaf.

§ 86. The tea leaf has a peculiar shape and microscopical structure; in the dried state of our ordinary tea the leaves are rolled up and crumpled, but when soaked and softened in warm water, their form is readily distinguishable. In order to examine the microscopical structure, slices so thin as to be transparent must be cut by a razor and examined by the microscope; this requires very considerable skill in manipulation, but a few years ago I devised methods which are much easier and require but little practice. One of these methods is to make the leaf transparent by a chemical means. A portion of a leaf is enclosed between two of the thin circles of glass used by all microscopists, and a weight having been placed upon the upper glass, the portion of leaf thus enclosed is heated with a strongly akaline solution of permanganate of potash. The action begins at once, and the substance under examination must be examined from time to time to see that the oxidation does not proceed too far; alkaline permanganate attacks the colouring matters, the contents of the cells first, and afterwards the cell membranes. The object of this treatment is to make the leaf transparent, and yet to preserve its structure. Tea leaves are very opaque, and it is impossible without some mechanical or chemical treatment to render them transparent. When from the appearance of the leaf fragment the oxidation is considered sufficient, it is removed, washed in water, and treated with a little strong hydrochloric acid,

Method of making a tea leaf transparent.

which at once dissolves the manganese oxide which has been precipitated on the leaf, and leaves the latter as a translucent white membrane, in which the details of structure can be readily made—tea leaf in this way being quite different in appearance from other leaves. The second method of great value is to place a fragment of leaf between two circles of glass, weight the upper one with a silver coin, and burn the leaf thus prepared on a bit of sheet platinum. Since it is impossible for the ash to curl up and

The skeleton ash.



Ash of aloe leaf. × 22.

Ash of tea leaf. × 170.

Ash of the leaf of the lime-tree.

FIG. 4.—SKELETON ASHES.

become disarranged, a complete skeleton of siliceous ash remains, which I have called "the skeleton ash." These skeleton ashes of leaves, so far as I have yet investigated show such decided differences the one from the other, that a great number of leaves may with a little practice be recognised by this method alone. Fig. 4 are examples of skeleton ashes.*

* The method of obtaining a "skeleton ash" is also extremely useful in detecting the adulteration of tobacco with foreign leaf.

Chemical composition of tea.

§ 87. The chemical composition of tea, if we have regard to every substance which can be extracted from it, is of great complexity. In my larger work on Foods I have enumerated no less than sixteen components, viz.—essential oil, theine, boheic acid, quercetin, tannin, quercetrinic acid, gallic acid, oxalic acid, gum, chlorophyll, resin, wax, albumen, woody and colouring matters, and ash.

Theine or caffeine.

It must however be remembered that many of these, such as wax, colouring matters, albumen, woody fibre, gum and resin, are common constituents of plants, and in no way are distinctive of the tea plant. The alkaloid theine, otherwise called caffeine, can be obtained in beautiful silky crystals of the whiteness of snow. Antony van Leeuwenhoek first discovered theine some time in the latter part of the 17th century, separating it from coffee beans by evaporating down the watery extract. He described the crystals as "oblong saline particles of different sizes, but most of them exceedingly minute; all of them with sharp points at the ends and dark in the middle." A hundred and twenty years afterwards it was rediscovered by a chemist (Runge) and separated in quantity from coffee.

Method of showing theine.

The presence of theine in tea is very easily demonstrated. Place one or two tea leaves in a teaspoon and add a little water, boil almost to dryness over a spirit lamp, then add a pinch of dry magnesia, and make the tea leaf and infusion into a sort of paste; on now carefully heating and holding a slip of glass over the spoon, theine will sublime or condense in crystals upon the glass.

Amount of theine in tea.

The quantity of theine in tea varies from 1 up to 3 per cent.; a cup holding half a pint of tea would, on an average, give 38 grains of solid matter, which would include 7⅓ grains of tannin and 2¼ grains of theine, with a fraction of a grain of essential oil.

The average composition of mixed tea, such as sold for 2*s*. 8*d*. per lb., is as follows.

——	Per cent.	In a pound, ozs. and tenths of an oz.
Water	11·49	1·8
Nitrogenous substances other than theine	21·22	3·4
Theine	1·35	0·2
Essential oil	0·67	0·1
Fat, chlorophyll and wax	3·62	0·6
Gum and Dextrin	7·13	1·1
Tannin	12·36	2·0
Other nitrogen-free matters	16·75	2·7
Woody fibre	20·30	3·3
Mineral matters* (ash)	5·11	0·8
	100·00	16·0

Value of tea. The table clearly shows that in a pound of tea, we only purchase 9 ozs. of active substances, hence even tea at 2*s.* a pound is a very dear article; a pennyworth of two shilling tea will only buy 162 grains of the components of the tea.

§ 88. *Coffee.* The coffee berry is the seed dried and deprived of its integument of the *Caffea arabica.* Nat. Ord. Cinchonaceæ; thin sections of the berry have a very marked and distinctive microscopical appearance, and show a very complex structure.

The use of coffee on the decline. The berry before use is always roasted. The use of coffee seems somewhat on the decline in England, the chief reason being the difficulty in ever purchasing a really good cup of coffee at an hotel or restaurant; and the few cooks in private houses who know how to prepare it properly. The whole secret of good coffee is to *grind* the *freshly roasted* berry, and use the ground coffee at once. The aroma is very delicate and fugitive, all attempts at full preservation seem to be failures.

Changes produced by roasting. The changes in the berry produced by roasting are the volatilisation of a small portion of the theine (caffeine), a partial change of the sugar into caramel, a general breaking

* The mineral matter of tea contains much potash and reacts alkaline; it is partly on account of this that tea leaves are found so useful in cleansing bottles, &c.

up of the oil and albumen cells, with the extrication of gas and water, and the development of a very powerful and volatile aromatic substance.

The general composition of coffee is as follows:

——	Parts per cent.	In a pound, ozs., and tenths of an oz.
Water	1·81	0·3
Nitrogenous substances other than theine	12·20	1·9
Theine (caffein)	0·97	0·2
Fat	12·03	1·9
Gum and sugar	1·01	0·2
Caffeo-tannic acid	22·60	3·6
Cellulose	44·57	7·1
Mineral matters (ash)	4·81	0·8
	100·00	16·0

Price of coffee as compared with tea.

Thus in a lb. of coffee, we do not purchase more than 8¾ ozs. of useful matter, a little less than in a lb. of tea. Although coffee ranges only from 1*s.* to 1*s.* 6*d.* a lb. it is dearer than tea, for the simple reason that so much more of the ground berries is required.

Chicory as an addition to Coffee.

§ 89. Chicory is a harmless root; with no particular physiological action, it is added to coffee because by its use a weak infusion of coffee has the appearance of a strong infusion. For the same reason it is a favourite ingredient in coffee extracts; the consumer sees a dark brown liquid, which tastes a little bitter, and imagines he is taking a good cup of coffee, whereas in reality he may be imbibing rather chicory infusion flavoured with coffee, than coffee flavoured with chicory. Of all substances used as food, none have been adulterated with such a variety as coffee; the berry in this country has been dealt with

unfairly from first to last, great companies have been started to substitute for it worthless ingredients; it has been coloured with sugar, fraudulently mixed with chicory, and all sorts of torrefied roots, and lastly, its proper method of use has never been popularised. Adulteration of coffee.

§ 90. *Cocoa and Chocolate.* The cocoa of commerce is made from the roasted seeds of the *Theobroma cacao*, a tree belonging to the natural order Byttneriaceæ, whole forests of which exist in Demerara. Cocoa is at present cultivated in Central America, Brazil, Peru, Caraccas, Venezuela, Ecuador, Grenada, Essequibo, Guayaquil, Surinam, some of the West Indian Islands, parts of the East Indies, the Philippine Islands, the Mauritius, Madagascar, and Bourbon.

The various names by which the cocoas of commerce are known, are those of the locality from which the cocoa has been derived.

The cocoa seeds intended for the manufacture of chocolate are submitted to a kind of fermentation (technically called the sweating process), during which they lose a certain disagreeable flavour, and develop an aromatic odour.

The commercial varieties of cocoa are very numerous. *Cocoa nibs* are simply the bruised, roasted seeds deprived of their coverings, and *flake cocoa* is composed of the nibs ground in a particular form of mill. The *soluble cocoas* are cocoas variously diluted with sugar and starches, for example, *Epps's cocoa* was proved in a legal action to be composed of 40 per cent. of cocoa, the rest starch and sugar. *Granulated cocoa*, *Homœopathic cocoa*, and *Maravilla cocoa* are all dilutions with sugar, and either arrowroot, sago or other starch. Commercial varieties of cocoa.

There are other preparations, like cocoa essence and cocoatine, which consist of pure cocoa deprived of its fat.

§ 91. *Chocolate* is made by grinding the nibs in a mill, the rollers of which are heated by steam; this softens the cocoa butter, and the pasty mass is mixed with sugar, and Chocolate: its mode of preparation.

flavoured with vanilla or other flavouring matters. The composition of cocoa and chocolate is as follows:

—	Pure Cocoa.	Chocolate.
Water	5·66	1·55
Cocoa butter	46·00	15·25
Theobromine	1·24	·41
Albumen, fibrin, and gluten	15·10	4·65
Starch	12·51	11·03
Sugar	..	63·81
Gum	7·20	*
Colouring matter	3·14	*
Woody fibre	5·90	1·15
Ash	3·25	2·15
	100·00	100·00

Theobromine and cocoa butter.

§ 92. The peculiar constituents of cocoa are two: viz. Theobromine and cocoa butter. Theobromine is an alkaloid analogous to theine; cocoa butter is a yellow concrete oil, of the consistence of tallow; it has a brown colour and agreeable taste; it never becomes rancid, however long it is kept.

When the large amount of starchy matter, fat, albumen, &c. is considered, cocoa and chocolate are seen to be as much a food as a drink. In 1 lb. of cocoa there are no less than 14 ozs. of useful matter; and at the average price of 15½*d.* per lb., for one penny 398 grains or nearly 1 oz. more or less nutritious substances are bought.

* Included with the starch.

DIVISION VII.

THE PRINCIPLES OF DIET.

CHAPTER XXVI.

THE PRINCIPLES OF DIET.

§ 93. THERE are diets suited for every age, for every climate, for every species of work, physical or mental; there are diets by which diseases may be prevented and cured, there are diets suited to some constitutions, injurious to others; diets which make the skin glossy, the frame vigorous, and the spirits joyous; others which mar the face with wrinkles, speckle the body with eruptions, and make the form hollow and lean, and prematurely old.

Good and evil powers of diet.

When, by successive researches, the science of diet is better understood, without doubt a school of physicians will arise, discarding all drugs, and treating maladies by cutting off certain foods, by surfeiting with others. If, indeed, at the present time there is not in the highest representatives of modern medicine, the nucleus of the future school of dietetics ready formed.

§ 94. It has already been explained that all food may be reduced to a few principles; that is, albumenous or nitrogenous matters, carbohydrates, fat, and mineral or saline matter. A person having for breakfast bacon, eggs, and toast, for dinner soup, vegetables, fish, meat and fruit, and for lunch a chop and bread, takes a variety of food which could not be compared with the simple rice diet of the Hindoo, were it not possible to reduce the elements to their equivalents, as albumenoids, carbohydrates, and the like.

The components of food for the purpose of comparison, must be reduced to their equivalents.

The process by which any one can do this I will endeavour to explain. In order to express food in

equivalents, only two things are required to be known ; one, the percentage composition of the food ; two, the weights of the food consumed.

How to express foods in equivalents.

In all scientific calculations the French weights are infinitely preferable ; but since to many of my readers, ounces and grains may be more familiar, I will use the latter.

The percentage composition of most common foods will be found in the tables, pages 349–354 ; how they may be employed may be shown from an example.

A person eats for dinner 2 ozs. of moderately fat beef, 4 ozs. of potatoes, 4 ozs. of cabbage, and 5 ozs. of bread—required the "*equivalents.*"

On referring to Table I. page 349, we see that 100 parts of moderately fat beef has a certain composition, and we have only to multiply the amounts given by $\frac{2}{100}$ that is ·02 to know the several amounts in 2 ozs. which will be, viz., water, 1·44, nitrogenous substances, ·43. Fat, ·10 ; ash (i.e., mineral substances), ·03. Similarly, the percentages of the components of the potato (Table V., page 353) have to be multiplied by $\frac{4}{100}$ or ·04, of the cabbage (Table V., page 353,) by $\frac{5}{100}$ or ·05 of bread (page 314) by ·04.

The whole 15 ozs. are then thus expressed in ounces and tenths.

—	Water.	Nitrogenous matters.	Carbo-Hydrates.	Fat.	Ash
The 2 ozs. of beef is equal to . . .	1·44	·43	..	0·10	·03
The 4 ozs. of potatoes*	3·03	·07	·82	0·01	·04
The 4 ozs. of cabbage*	3·60	·07	·20	0·01	·05
The 5 ozs. of bread .	1·92	·34	·04	2·62	·06
	9·99	·91	1·06	2·74	·18

The totals added together make 14·88 ozs., ·12 ozs. being woody fibre, and therefore not included.

* The woody fibre need not be reckoned.

It is often convenient to make a still farther reduction, and express the food as so many grains of nitrogen and carbon.

This may be done by multiplying the nitrogenous matters as calculated out in ounces, by 69 for nitrogen, and 233 for carbon; multiplying the fat by 345·6 for carbon, and the carbohydrates (except milk or sugar) by 194·2 for carbon.

	Grains of Nitrogen.	Grains of Carbon.
Thus, ·91 ozs. of nitrogenous (albumenoids) matter . =	62·8	212·0
1·06 oz. of carbohydrates = . .		205·8
2·74 ozs. of fat = . . .		946·9
	62·8	1364·7

§ 95. The researches of a great number of physiologists and chemists have now laid down the true principles of diet in relation to physical work. The standard diet for ordinary labour, after reckoning out the water, is as follows:— Standard diet.

	Ozs.	Grains.
Albumenoids . .	4·2 =	290 nitrogen
Fat	1·6	
Carbohydrates .	18·7 =	4184·4 carbon
Salts . . .	1·05	459·3 mineral substances

The diet of the English soldier consisting of 12 ozs. of meat (1/5 bone), 24 ozs. of bread, 16 ozs. of potatoes, 3 ozs. of other vegetables, 3¼ ozs. of milk, 1·3 ozs. of sugar, with salt, tea and coffee, is about equal to the standard diet, being equivalent to 266 grains of nitrogen and 4718 grains of carbon.

On such a diet 300 tons may be lifted one foot daily (see page 271), and health and strength be maintained.

§ 96. König has made a useful comparison of the cost of the different principles of a standard diet, according as it is derived from the animal or vegetable kingdom; he has taken as his basis the albumenoids in ordinary half-fat beef, as contrasted with the albumenoids in potatoes; similarly, he Cost of the food equivalents of animal and vegetable diets compared.

has taken the fat as lard; and he has reckoned out its equivalent in carbohydrates from the researches of Voit and Pettenkofer, who have shown that 100 of fat is equal to 175 of starch in its work in the economy. The comparison is, of course, based on the German prices, viz., meat, 7½*d.* per lb.; lard, 9½*d*; and potatoes about ½*d.* per lb. Our English retail prices in London differ somewhat from this; meat and potatoes being dearer. Nevertheless, the comparative difference, which may be very well shown on König's calculations, translating kilogrammes and marks into pounds and shillings, is as follows :—

	Animal food. per lb.	Vegetable food. per lb.
	s. *d.*	*s.* *d.*
Albumenoids	3 0	1 3
Fat	1 0	0 9
Carbohydrates	1 2½	0 3

If labourers lived on meat alone, their wages would have to be very high; the commonest meat and meat fat to make up the standard diet would cost in this country something like 1*s.* 8*d.* daily, or not far off 12*s.* a week.

The poor man's diet must be a proper mixture of the expensive animal diet with the cheap vegetable diet: such as that given at page 341.

The embryo fed chiefly on albumen.

§ 97. *Diet in development.* It is a curious fact that the earliest food is not the starchy or carbohydrate, but the albumenous. The hen's egg, the changes in which have been so fully worked out by means of artificial incubation, is a good example of this. The body of the chicken is formed out of the yellow yelk, which is the little bird in an unarranged state. The white is almost pure albumen and water, around all is the shell, part of which is to be dissolved by the albumen and carried to the yelk to form the bones. During the whole period, the developing egg diminishes in weight from the loss of carbonic acid and water, the albumen becomes slowly assimilated into the substance of

the chicken, and lastly, the shell is attacked and thinned. The chicken thus grows at the expense of its surrounding food, and when it at length frees itself from the shell, there is scarcely anything left for it to live upon, the little bird then seems to be built up entirely on albumen and salts; but if you make the attempt to feed adult birds with white of egg, and finely ground shells, they die of starvation; Tiedemann and Gmelin indeed tried the experiment with geese, but that same food which would have given to the young embryo all the sustenance required, starved and killed the adult. The embryo of mammals is no doubt nourished in a less simple way, and probably extracts carbohydrates, in the form of sugar, from the circulating blood stream, common to both parent and offspring. As soon as born the mammalian infant lives upon albumenous and sugary matters (see milk, p. 301), and after some time develops its digestive organs sufficiently to take a mixed diet; but in the earliest years the human infant is more of a carnivorous than an omnivorous animal.

The human infant at first easier digests flesh products than starch products.

§ 98. The nearer a young infant's diet approaches to milk the better, but older children can consume very large quantities of carbohydrates in the form of starches. Voit made an elaborate investigation on the diet used in the Orphan Asylum at Munich, in which the children of from 6–15 years of age are maintained in excellent health. An example of a day's ration is as follows:

Diet of young children above six years of age.

Breakfast: 9 ozs. of milk, 1·4 ozs. of bread.

Mid-day meal: a vegetable dish made of 1·8 ozs. of cabbage, 6 ozs. of flour, ·4 lard with onions, 6 ozs. of beef including bone, mashed potatoes made of 7 ozs. of potatoes, 5 ozs. of flour, 3 ozs. of lard and a couple of onions; also bread 2·8 ozs.

Afternoon: bread 2·8 ozs.

Evening meal: bread 2·8 ozs., beer, half-pint, 9·9 ozs. potatoes, cut in slices with ·4 ozs. of lard.

Taking the whole week through, the average daily equivalents are:

Albumenoids	2·7 ozs.
Fat	1·3 ozs.
Carbohydrates	8·7 ozs.

which is equal to 169½ grains of nitrogen and 4·451 grains of carbon. Hence, although growing children do not seem to require so much nitrogen as adults, they require quite as much or even more sugar, starch, and fat—the fondness of young people for sweetmeats, cakes, and pastry being based upon a physiological necessity.

Diet for body work.

§ 99. *Diet suitable for great physical efforts contrasted with that suitable for sedentary pursuits.* When there is excessive exertion the elements of the diet must be increased proportionate to the effort. Some addition to our knowledge of the quantity of food required, to keep the system in health, has recently been afforded us in observations upon Mr. Weston during the 6 days in which he concluded his pedestrian feat. The external work was walking 50 miles daily on a level track in the Victoria Hall, which I have calculated to be equal to lifting 793 tons one foot high.

Weston's diet.

Weston, while under observation at the Victoria Hall, would breakfast at 6·30, on 12 ozs. of porridge, 3 eggs (or if he did not have eggs he had nine or ten ozs. of fish), with from 2 to 5 ozs. of toast, bread and butter, or muffin, and from ½ a pint to a pint of coffee.

At eleven he lunched on from 6 to 8 ozs. of bread and butter, and a pint or more of coffee.

At half-past two p.m. he dined on about one pint of mutton broth, from 6 to 11 ozs. of either beef or mutton, as free from fat as possible, 4 ozs. of potatoes, 5 ozs. of cabbages, 4 to 5 ozs. of bread and butter or toast, and 12 ozs. of a tapioca pudding, taking soda water or ginger ale as a drink.

At 7 p.m. he had a small quantity of toast, and a pint or more of tea or coffee.

At 10.30 he had some toast, some figs, 2 ozs. of sponge cake, and from 8 to 20 ozs. of pudding, sometimes milk, sometimes soda-water.

I have reduced the daily diet to equivalents, as in the following table.

FOOD EQUIVALENTS OF THE DIET USED BY MR. WESTON WHILST WALKING 50 MILES DAILY ON THE LEVEL TRACK IN THE VICTORIA HALL.

—	Water. ozs.	Albumenoids. ozs.	Carbohydrates. ozs.	Fat. ozs.	Ash. ozs.
Monday . . .	137·9	8·0	27·5	1·6	0·8
Tuesday . . .	109·6	7·8	24·7	1·8	0·7
Wednesday . .	146·2	8·6	27·7	3·3	1·1
Thursday . .	130·4	8·7	32·0	1·6	0·7
Friday . . .	145·0	8·5	30·6	3·1	0·7
Saturday . .	140·3	5·8	19·5	2·5	0·6
Total . . .	809·4	47·4	162·0	13·9	4·6
Mean . . .	134·9	7·9	27·0	2·3	0·7

This diet is equivalent to 545 grains of nitrogen and 7879 grains of carbon daily, or rather more than twice the amount of nitrogen, and about twice the amount of carbon which will support ordinary work. It will be instructive to compare with these large quantities of food, which in order to perform the task effectually were really necessary, the diet of people who live, whether from indolence or necessity, vegetative lives, with but little physical and less mental exertion. One of the best examples of the small amounts required to support life is that of the Trappist monks. Their diet is interesting, not alone because it is well authenticated, but because it is wholly vegetable. It indeed consists only of black bread and vegetables. There are three meals daily, and the average daily ration is $17\frac{1}{2}$ ounces of bread, $17\frac{1}{2}$ ounces of beer, two plates of vegetable soup, and one plate of greens. This reduced to equivalents would be 2·4 ounces of albumenates, 4 ounces of fat, and 16·5 ounces of carbohydrates, or 165 grains of nitrogen, and a little over 5000 grains of carbon—the carbon is therefore about or a little over that of the standard diet (page 341), the nitrogen is about $\frac{1}{5}$ less.

Vegetable diet of the Trappist monks.

§ 100. Some years ago there was a sort of an experi-

ment made on certain prisoners in Glasgow. Ten prisoners were under sentence of two months' imprisonment each. They were all employed at very light work, involving no great muscular exertion. At the commencement all were in good health; two were in indifferent health. At the end all were in good health, and the average gain of weight* per man was four pounds; one had gained as much as nine pounds, and one had lost somewhat in weight. The diet consisted of three meals a day, and the total quantity per man was 13 ounces of oatmeal, 3 pounds of boiled potatoes, and 1¼ ounces of buttermilk. It was equal in equivalents to 164 grains of nitrogen and 4·643 grains of carbon.

Diet of oatmeal, buttermilk, and potatoes.

This again shows that for light work the meaty class of substances may be much decreased.

Diet for brain work.

§ 101. *The diets for mental exertion.* This is a difficult subject, we know so little of the true food of the brain; what we do know is that morbid fancies are often but the emanations of a brain poisoned by impure blood; and that food, digestion, and morals have a more intimate connection than theologians are prepared to accept.

The brain must not be "filliped" up with brandy.

One of the first laws to which men working their brains must submit to is the greatest moderation in the use of alcoholic drinks. To take a glass of light ale with a meal for the sake of digestion is one thing, but to stimulate the flagging brain with brandy or wine is another, and is likely to produce early disease and premature exhaustion. When the brain is tired, it must be renovated by sleep and bodily exercise.

The brain, together with the nervous system, is chemically composed of a number of phosphorised fats set in an albumenous framework. It has never been proved that there is any real waste of the phosphorus compounds under prolonged mental exertion; nor is it precisely known whether there is any metabolism of these compounds; but judging by analogy just as the muscular

* Gain or loss of weight is in itself of no value as a criterion of health; the men showed however general signs of good health.

system requires organic nitrogen, the brain may require organic phosphorus. The diets most rich in organic phosphorus are fish diets and egg diets; and not a few eminent men, engaged in hard mental work, take fish under the idea that it is of greater assistance to them than an equal amount of nutriment in beef or mutton.

Does the nervous system require organic phosphorus.

Whether these theories have a proper basis or not, this one thing is certain, that any form of indigestion greatly interferes with mental effort, either causing somnolence, apathy, or irritability; so that those diets which the worker knows will best agree with him, are, *cæteris paribus*, best for his brain.

§ 102. *The reduction of fat by diet.* A method for the removal of unhealthy and inconvenient fat was some years ago brought prominently before the public by Mr. Banting—the Banting system in its essence was known to Hippocrates, Celsus, Galen, and to Æsculapius and his school and previous to Mr. Banting's little book, an exact and clear account of the proper principles of reducing fat was published by Brillat-Savarin, for in his famous '*Physiologie du Gout,*' 1843, after saying that the first cause of obesity is predisposition, he continues: "The second and principal cause is in the flours and starches, of which man makes the daily basis of his nourishment. The starch produces its effect most quickly when mixed with sugar."

How to get lean.

Brillat-Savarin.

The man who makes widely known a useful fact or invention is often as useful to the world as the discoverer, and Mr. Banting's little octavo pamphlet, called 'The Letter on Corpulence,' will always be rightly considered an important contribution to practical dietetics. Mr. Banting weighed 202 lbs., or over 14 stone. In a little more than 12 months he reduced it by 50 lbs., and became 10 st. 12 lbs. His diet was, for breakfast, beef, mutton, or kidneys, bacon, or cold meat of any kind, except pork or veal. He took tea or coffee, and one ounce of dry bread. The total amount of meat was between five and six ounces, which, with the bread, makes six or seven ounces. For dinner he took any fish except the fatter kinds, that is, salmon, eels or herrings,

Mr. Banting's diet.

Any meat and any vegetables, except potatoes, parsnip, beetroot, or carrot. He had some dry toast, some fruit out of a pudding, and poultry or game. He took a little wine, and altogether seems to have consumed eleven or twelve ounces of meat and vegetables, and one ounce of bread. For tea he had fruit, a rusk or two, and tea without milk or sugar. For supper he again had meat, taking about four ounces, and he finished the day with a glass of grog.

It is to be regretted that the foods and liquids he took day by day were not recorded with scientific exactness; but if I have read his pamphlet aright, he took altogether of meat something like 19·5 ozs., of starchy substances, 6 ozs., about equivalent to 338 grains of nitrogen, and 1617 grains of carbon. The food was extremely deficient in fat and carbo-hydrates, containing about $\frac{1}{6}$th of the quantity of fatty and starchy substances which ordinary people would use. The fat-forming substances being thus decreased, by cutting off the supply; the excess of nitrogenous food by its peculiar action (see page 283) increasing the oxidation, the metabolism of the body aided the dimunition of the various fat-stores of the body.

People inclined to be inconveniently fat may profitably use a partial or modified Banting system. An abstinence from sugar, the sparing use of bread, pastry and potatoes, and a plentiful supply of lean meat, combined with exercise, ought to be sufficient to restrain the proportions of most people within due limits. On the other hand lean people who desire to get fat, must use a diet opposite to this; eat little lean meat, plenty of butter, potatoes, bread, and pastry: they must live in warm rooms, and take little exercise. These are, indeed, the principles upon which animals are fattened, but there are certain men who will always be lean and anxious-looking, such have peculiar irritable nervous organisations, and the metabolism of their tissues is very active.

How to get fat.

APPENDIX.

TABLE I.

PERCENTAGE COMPOSITION OF VARIOUS ANIMAL FLESH OR MEAT.

—		Water.	Nitrogenous substances.	Fat.	Nitrogen-free extractive matter.	Ash.
Bacon fat, salted and dried		13·9	9·0	74·1		3·0
Beef (fat)	minimum	32·49	10·87	5·80		0·75
	maximum	73·50	19·94	56·11		1·53
	mean	54·76	16·93	27·23		1·08
Beef (moderately fat)	minimum	68·50	16·99	1·00		0·75
	maximum	78·00	25·03	9·86		2·02
	mean	72·25	21·39	5·19		1·17
Beaf (lean)	minimum	75·21	20·18	0·61		1·14
	maximum	78·16	22·17	3·46		1·20
	mean	76·71	20·61	1·50		1·18
Fowl		70·82	22·65	3·11	2·33	1·09
Hare		74·16	23·34	1·13	0·19	1·18
Kidney (sheep's)		78·60	16·56	3·33	0·21	1·30
Mutton	very fat	47·91	14·80	36·39	0·05	0·85
	moderately fat	74·79	18·11	5·77		1·33
Pigs' liver		72·37	18·65	5·66	1·81	1·51
Pork (fat)	minimum	40·27	12·55	28·03		0·47
	maximum	54·63	16·58	46·71		1·07
	mean	47·40	14·54	37·34		0·72
Pork (lean)	minimum	69·32	17·32	3·73		0·98
	maximum	76·14	24·47	11·77		1·64
	mean	72·18	19·91	6·81		1·10
Tripe		67·1	13·3	17·1		2·50
Veal	(fat)	72·31	18·88	7·41	0·07	1·33
	(lean)	78·82	19·86	0·82		0·50
Eggs (hen's)		73·67	12·55	0·35		1·12
Egg albumen (white)		86·49	12·67	0·25		0·59
Egg, yelk of (yellow)		50·79	16·24	31·75	0·13	1·09

TABLE II.

PERCENTAGE COMPOSITION OF FISH.

—	Water.	Nitrogenous substances.	Fat.	Nitrogen-free and extractive matter.	Ash.
Codfish	77·50	18·50	3·00		1·00
Eels	79·91	13·57	5·02	0·39	1·11
Gudgeon	76·89	17·37	2·68		3·44
Herrings, fresh	80·71	10·11	7·11		2·07
Herrings, salted	47·12	18·97	16·67		17·24
Herrings, smoked	69·13	21·12	8·51		1·24
Lamprey	51·21	20·18	25·59	1·61	1·41
Mackerel, fresh	68·27	23·42	6·76		1·55
Mackerel, salted	48·43	20·82	14·10	0·38	16·27
Oyster	89·69	4·95	0·37	2·62	2·37
Pike	77·37	19·86	0·79	1·60	0·38
Salmon	71·50	18·75	6·22	2·95	0·58
Sardine (preserved)	51·77	22·30	2·21		23 72
Skate	73·79	24·03	0·47		1·71
Sole	86·14	11·94	0·25	0·45	1·22
Sprat	59·89	22·73	15·94	0·98	0·46
Whiting	82·95	15·09	0·38	0·50	1·08

TABLE III.

Percentage Composition of Milk, Cheese and other Dairy Products.

—	Water.	Casein and albumen.	Fat.	Milk-sugar.	Ash.
Milk	87·55	3·41	3·64	4·69	0·71
Skim milk	90·11	3·37	0·46	5·34	0·72
Cream	28·58	1·42	67·63	2·25	0·12
Devonshire cream	28·68	4·05	65·01	1·77 (Lactic acid ·32)	0·49
Buttermilk	90·62	3·78	1·25	3·38	0·65
Condensed milk (preserved with the addition of cane sugar)	24·42	10·33	9·02	Milk sugar 12·64 (Cane sugar) 41·66	1·93
Condensed milk (without any addition)	48·59	17·81	15·67	2·53	35·00
Butter	14·14	0·86	83·11	0·70	1·19
Butterine	12·01	0·74	82·03		5·22
Cheese.					
1. *Soft Cheeses.*					
Fromage de Brie	51·87	18·30	24·83		5·00
Camembert	51·30	19·00	21·50	3·50	4·70
Roquefort (fresh)	11·84	85·43	1·85	Lactic acid 0·88	11·84
2. *Hard Cheeses.*					
American cheese	22·59	37·20	35·41		4·80
Cheddar cheese	27·83	44·47	24·04		3·66
Dunlop cheese	38·46	25·87	31·86		3·81
Gloucester (single)	21·41	49·12	25·38		4·09
Stilton (fresh)	32·18	24·31	37·36	2·22	3·93
Gruyère	34·68	31·41	28·93	1·13	3·85
Gorgonzola	43·56	24·17	27·95		4·32
Parmesan	27·56	44·08	15·95	6·69	5·72
Skim cheese	48·02	32·65	8·41	6·80	4·12

TABLE IV.

PERCENTAGE COMPOSITION OF VARIOUS FLOURS AND LEGUMINOUS MEALS.

—	Water.	Nitrogenous substances.	Fat.	Starch, &c.	Woody fibre.	Ash.
1. *Meal.*						
Barley meal . . .	15·06	11·75	1·71	70·90	0·11	0·47
Buckwheat meal . .	14·27	9·28	1·89	72·46	0·89	1·21
Maize						
Oatmeal	10·46	15·50	6·11	63·67	2·24	2·02
Rye meal	14·24	10·97	1·95	69·74	1·62	1·48
Wheaten flour (fine) .	14·86	8·91	1·11	74·18	0·33	0·61
" (seconds)	12·18	11·27	1·22	73·65	0·84	0·84
2. *Starch.*						
Arrowroot . . .	16·52	0·88		82·41		0·19
Maize starch . . .	11·90	2·37		85·30		0·43
Sago	12·89	0·81		86·11		0·19
Tapioca	13·3	0·63		85·95		0·12
Wheat starch . . .	11·30	1·12		87·05		0·53
Macaroni (stars) . .	14·01	8·69	0·32	76·49		0·49
" (pipe) . .	15·86	8·19	0·29	75·06		0·60
3. *Leguminous Seeds.*						
Beans (fresh and green)	86·10	4·67	0·30	6·60	1·69	0·64
" (dried) . . .	14·84	23·66	1·63	49·25	7·47	3·15
Peas (green) . . .	80·49	5·75	0·50	10·86	1·60	0·80
" (dried) . . .	14·31	22·63	1·72	53·24	5·45	2·65
" (shelled) . . .	12·73	21·12	0·82	60·94	2·64	1·75
Pea meal (dried) . .	8·12	28·10	2·97	50·17	8·02	2·55
Kidney beans . . .	88·36	2·77	0·14	1·20 Sugar 6·82	1·14	0·57
Lentils.	12·51	24·81	1·85	54·78	3·58	2·47
Millet	11·26	11·29	3·56	67·33	4·25	2·31

TABLE V.

PERCENTAGE COMPOSITION OF SUCCULENT VEGETABLES.

—	Water.	Nitrogenous substances.	Fat.	Carbohydrates. Sugar.	Carbohydrates. Nitrogen free extractive m. tter.	Woody fibre.	Ash.
Asparagus	93·32	1·98	0·28	0·40	2·34	1·14	0·54
Beet, common	87·88	1·07	0·11	6·55	2·43	1·02	0·94
Beet, sugar	83·91	2·08	0·11	9·31	2·41	1·14	1·04
Cabbages	89·97	1·89	0·20	2·29	2·58	1·84	1·23
Carrots	87·05	1·04	0·21	6·74	2·60	1·46	0·90
Celery, leaves	81·57	4·64	0·79	1·26	7·87	1·41	2·46
Celery, stalks	89·57	0·88	0·34	0·62	5·94	1·24	1·41
Cauliflower	90·39	2·53	0·38	1·27	3·74	0·87	0·82
Chicory, dried and roasted	10·69	6·29	1·52	15·54	55·00	6·11	4·85
Chicory, fresh	75·69	1·01	0·49	3·44	17·62	0·97	0·78
Cucumber	95·60	1·02	0·09	0·95	1·33	0·62	0·39
Garlick (leaves and stalks)	90·82	2·10	0·44	0·81	3·74	1·27	0·82
Horse-radish	76·72	2·73	0·35		15·89	2·78	1·53
Lettuce	94·33	1·41	0·31		2·19	0·73	1·03
Onions (bulbs)	64·66	6·76	0·06		26·31	0·77	1·44
Parsley	85·05	3·66	0·22	0·75	6·69	1·45	1·68
Potatoes	75·77	1·79	0·16		20·56	0·75	0·97
Radishes	93·34	1·23	0·15	0·88	2·91	0·75	0·74
Savoys	87·09	3·31	0·71	1·29	4·73	1·23	1·64
Spinach	90·26	3·15	0·54	0·08	3·26	0·77	1·94
Turnips	85·01	2·95	0·22	0·40	8·45	1·76	1·21
Water-melon	95·21	1·06	0·60	0·27	1·16	1·07	0·63

TABLE VI.

Percentage Composition of Fruits.

—	Water.	Nitrogenous substances.	Free Acid.*	Sugar.	Nitrogenous-free substances, extractive matter, &c.	Cellulose and seeds.	Ash.
Almonds	5·39	24·18		fat 53·68	7·23	6·56	2·96
Apple	83·58	0·39	0·84	7·73	5·17	1·98	0·31
Apricot	81·22	0·49	1·16	4·69	6·35	5·27	0·82
Bilberry.	78·36	0·78	1·66	5·02	0·87	12·29	1·02
Blackberry	86·41	0·51	1·19	4·44	1·76	5·21	0·48
Chestnut	51·48	5·48		fat 1·37	38·34	1·61	1·72
Cherry	80·26	0·62	0·91	10·24	1·17	6·07	0·73
† Cocoa nut, white solid part . . .	5·32			fat 66·16		?	1·55
Currant	84·77	0·51	2·15	6·38	0·90	4·57	0·72
Damson	81·18	0·78	0·85	6·15	4·92	5·41	0·71
Figs (as sold) . . .	31·20	4·01	1·21 also fatty matter 1·44	49·79	4·51	4·98	2·86
Filberts	3·77	15·62		fat 66·07	9·03	3·28	1·83
Gooseberries . . .	85·74	0·47	1·42	7·03	1·40	3·52	0·42
Grapes	78·17	0·59	0·79	24·36	1·96	3·60	0·53
Mulberries	84·71	0·36	1·86	9·19	2·31	0·91	0·66
Oranges.	89·01	0·73	2·44	4·59	0·95	1·79	0·49
Peach	80·03	0·65	0·92	4·48	7·17	6·06	0·69
Pears	83·03	0·36	0·20	8·26	3·54	4·30	0·31
Plums	84·86	0·40	1·50	3·56	4·68	4·34	0·66
Raisins	32·02	2·42		54·56 also fatty matter 0·59	7·48	1·72	1·21
Raspberries . . .	86·21	0·53	1·38	3·95	1·54	5·90	0·49
Strawberries . . .	87·66	1·07	0·93	6·28	0·48	2·77	0·81
Walnuts	4·68	16·37		fat 62·86	7·89	6·17	2·03

* The free acid which gives the sourness to fruits is different in different fruits. The chief free acid of the apple, pear, plum, apricot, peach and cherry is malic acid; that of the grape, tartaric acid; in oranges and lemons, citric acid; and in strawberries and raspberries, the acidity is due to a mixture of citric and malic acids.

† Cocoa-nut milk contains water 91·50, nitrogenous substances ·46, fat ·07, nitrogen-free extractive matters 6·78, ash 1·19 per cent.

FOOD AND COOKERY

FOR

INFANTS AND INVALIDS.

BY

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WITH AN INTRODUCTORY CHAPTER

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CONTENTS.

FOOD AND COOKERY

FOR

INFANTS AND INVALIDS

INTRODUCTORY.

THE human body exists in a state of perpetual, unceasing change. It is built up of varied materials, some of which, indeed, as for example the mineral parts of bone, are fixed and enduring ; but the majority—and these the most vital and important—brain, and nerve, and muscle, and gland, are delicate and unstable ; constantly wearing away and as constantly repaired.

There is then ceaseless need for new matter to replace old and worn out matter as unceasingly removed.

The body, however, requires materials for other important purposes ; as fuel for combustion, in order to keep the temperature of the body at the necessary heat, and for the supply of force or energy for every movement and action and operation of organic life.

There is, moreover, in young creatures a need of materials for another grand purpose in addition—the structure and development of new parts. Now the animal body can make little use of raw materials—of the primary elements in their simple form—either for building or repair. Muscle, for example, consists largely of nitrogen, combined with carbon

oxygen, hydrogen and sulphur in definite proportions. Yet an animal although plunged overhead in an atmosphere four-fifths of which is nitrogen, has no power of taking so much pure nitrogen, and uniting it with the necessary proportion of the other elements to make muscle. This first step of joining the primary elements together is effected by plants, which take up the crude materials from earth, air, and water, and form them into definite compounds. These, fixed in their stems, fruit, or seeds and roots, are consumed by animals, and thus passed on to the higher organism. They are, however, not yet finally prepared for use in the animal body; they are not fit for absorption. They require to be rendered soluble, by digestion, so that they may pass easily into the blood, and be carried by the fertilising stream to every cell and tissue of every part of the structure.

The products thus originally manufactured by plants and used again by animals, are grouped into four chief classes, according to their composition and the purposes which they serve.

The first group is that of the nitrogenous materials, characterised by the presence of *nitrogen*, and styled also albuminates, or proteids. They form one of the distinguishing features of animal food, in which they are found more abundantly than in vegetable products; the albumen of white of egg, casein or curd of milk, the syntonin of muscle, and the gluten of wheat, are familiar examples of these elements.

The second group is that of the hydrocarbons, substances which contain *carbon* in high proportion. These are the fats, such as that of meat, butter and vegetable oils, found both in animal and vegetable substances, but more plentiful in the former.

The third group is that of the carbohydrates, also distinguished by the presence of carbon, but in less proportion. Starch and sugar are common examples of elements in this group, the abundant presence of which is as characteristic of vegetable as that of nitrogenous elements is of animal foods.

The fourth group is that of inorganic or mineral elements—such as the salts of lime, especially the phosphates and carbonates; potash, soda, iron and—one of the most important and largely-used of all—water.

From numerous observations and experiments it would appear that, in order to afford perfect nourishment to the body, food should contain materials drawn from each of these four groups. And it has been ascertained further, with great accuracy in the case of healthy adults, that ingredients from each of these classes should be mingled in the following proportion.

Proteids (Nitrogenous elements)	1	part.
Hydrocarbons (Fats)	0·6	"
Carbohydrates (Starch, sugar, etc.)	3	"
Salts (Mineral)	0·23	"
Water, about	15	parts.

In the case of little children, where the body is still in process of construction, and its power, as yet imperfectly developed, and in that of invalids, where the machinery is deteriorated or enfeebled or injured by disease, these standard proportions require to be modified in many important particulars.

We may consider first the modifications required in the case of infants, and the principles upon which their dietary should be based. And this question of children's food is one of the greatest moment. It is not merely a question of present good, and of transient importance, but one which affects their whole future. There is no doubt an infinite variety in the constitution of individuals. In some the machinery is weak and faulty in construction, without capacity for development into any high degree of strength and perfection.

The peculiarities of original constitution can, however, be largely modified by external influences; the feeble and imperfect body, which under adverse circumstances would dwindle and die, may be fostered by favourable conditions into some degree of vigour and stability: the well-made body of rich possibilities, which under evil

surroundings would degenerate and grow stunted and deformed, may be aided to expand into full glory of power and beauty. Of the influences which thus affect the development of the young organism food is one of the most potent.

And just as a plant requires not only a rich and fertile soil, but one adapted to its special habit and character, to bring it to full perfection and luxuriance, so does a child require fertile food adapted to its particular needs, to enable it to reach the highest degree of development of which it is capable.

For a little child, as for an adult, it is essential that food should contain elements from each class. With children, too, as with grown persons, the nitrogenous bodies or proteids rank first. They feed brain, and muscle, and gland; protoplasm, the centre of life and energy in every cell, is formed out of them and nourished by them. Every structure in the body in which any form of force is manifested is nitrogenous. Nitrogen, indeed, is essential to every vital process. Without it all functions of the body languish; all vigour and power dwindle and die out.

It will be readily understood, then, that if a sufficient supply of nitrogenous matter is of the first importance to mature adults, it is still more essential to children; who, in addition to the routine work of maintaining the body, have to provide materials and vital energy for the building of new structures.

The second group of elements, the hydrocarbons, is inferior in importance only to the preceding. Fat, like protoplasm, appears to form a necessary part of every cell, enters largely into the composition of brain and nerve, and the marrow of bone, and it is stored up for some purpose in all nooks and corners of the frame. Probably its chief office is to serve as fuel—for food is burnt in the body, just as oil is burned in a lamp or coal in a furnace. It is thus that the heat required to keep the body at the standard temperature necessary to the vitality of its fluids and solids is supplied; and with heat its corelative—force.

In the case of infants, again, we see that this element of food must be pre-eminently needed. It is wanted for all tissues formed and forming, especially for brain and nerve, for the marrow cells, which are the active agents in building up bone, and for the generation of heat and energy, so largely called upon in the period of early growth.

The succeeding group of food elements, the carbohydrates, of which starch and sugar are the chief representatives, do not appear to form parts of the more solid tissues as such; although they are present in the fluids. They are largely converted into fat; and serve also, perhaps, as a lighter kind of fuel for combustion. These elements seem, therefore, to possess less intrinsic value than the proteids or the fats. Yet they are probably essential in some form to the perfect nutrition of both the adult and growing organism.

The inorganic or mineral constitu-nts, which form the remaining group of food elements, are far more indispensable to children than to older persons. They supply materials for the permanent structures, such as salts of lime and magnesia for the bones, in the form of phosphate and carbonate. These earthy phosphates, again, are essential to every tissue—probably no cell growth can go on without them—even the lowest forms of life, such as micrococci and bacteria, cannot grow if deprived of them.

Such being the materials required by the growing body of the child, and their relative importance; in what proportion should each be given? How much proteid? How much fat? How much starch or sugar? Should the proportions be the same as for grown persons?

The answer is supplied by nature; the proportions should *not* be the same; for they are not the same in the type food, the mother's milk. As an egg supplies everything from which the chicken is formed complete, with bone and flesh, skin and feathers, so milk contains everything necessary for the perfect formation and nourishment of the child. It contains the nitrogenous proteid in the shape of casein or curd, hydrocarbon in the form of butter, carbo-

hydrate in the form of lactine or sugar of milk, mineral matter, and water.

The proportions in human milk are:

Proteids	3·924
Fat	2·666
Lactine	4·364
Salts	0·138
Water.	88·908
	100·000

Now, as will be seen on reference to the table on a preceding page, in an adult diet the proteid is to the carbohydrate as one to three ; in woman's milk, as will be seen, it is nearly equal. Fat in adult diet is in the proportion of six to three of carbohydrate ; here rather more than one to two. That is, *in the typical infant's food as compared with the standard diet for an adult the proportion of nitrogenous matter is nearly trebled, that of fat nearly doubled, in proportion to the carbohydrate.* This we may take as the standard for an infant ; and to this standard a child's food, in whatever form it be given, should very closely conform.

There is another quality in food essential to the healthy nutrition of infants—the antiscorbutic property. It is found that with adults every dietary must contain a certain amount of fresh vegetable food, or scurvy follows. The exact nature of the ingredient which confers the antiscorbutic power has not been ascertained with certainty ; it is undoubtedly present in fresh vegetable juices, and has been traced to organic acids in combination with potash. Yet children fed on fresh milk never suffer from scurvy, although they get no fresh vegetables. So that fresh milk must possess, in addition to the other essential elements, this mysterious antiscorbutic element, which in an ordinary diet is supplied by fresh vegetables ; a quality which has hitherto received very little recognition. It would seem, however, that condensed milk loses this special virtue, and all the artificial foods are destitute of it. If, therefore, for any reason a child cannot be fed on fresh milk, the antiscorbutic element must be

specially supplied to the artificial food substituted for milk. This is a vital point, essential to full health ; yet its great importance is most inadequately recognised in practice. Another condition which must not be overlooked in an infant's diet is that it should contain a due proportion of animal food. It is difficult to supply sufficient nitrogenous matter in vegetable food, which contains it in smaller proportion ; and it is practically impossible to supply sufficient fat from vegetables ; for in the available forms, such as the farinaceous preparations, it is present in far smaller proportions still. Even maize, the richest of all grains in fat, contains only seven per cent., and that, after the requisite dilution with seven to sixteen parts of water, would be far below the necessary standard. But apart from this difficulty, it would seem that, even if sufficient of these ingredients could be given in vegetable form, some portion of food at least should be of animal origin—for milk, the type food of infants, is of course *entirely* animal. Animal tissues are probably most easily made from animal materials—and little children brought up on vegetable food alone are constantly soft, flabby and bloodless, rickety, scorbutic. Yet nearly all the artificial infant's foods in vogue are entirely vegetable. Further, it is to be remembered that young infants have very imperfect powers of digestion. The digestive organs have only just come into use, and are designed only to deal with the bland and easy nutriment of the mother's milk. During the early months of life young animals, and human infants amongst them, have little power of digesting starch. It is not an ingredient of their natural food, milk, which contains absolutely none. The carbohydrate element is in the form of lactine, or sugar of milk. Yet although nature has not endowed young infants with the means of dealing with starch, and it cannot therefore be a proper element of their food, most artificial foods, with profound indifference to physiological teaching, have starch as their chief ingredient !

A second notable deficiency in the digestive power of infants is, that of dealing with anything like large masses of solid matter. Neither the solvent power of their digestive

juices, nor the muscular power of the stomach is equal to this. This is seen in the digestive disorder often produced by cow's milk when coagula of curd are passed from the bowels, or rejected by the stomach undissolved; and in the same way the insoluble cellulose or woody fibre of the coarser vegetable products prove irritating and injurious. Lastly, the stomach of a little child is extremely intolerant of food which is in a state of fermentation, or is affected with the least taint of decomposition. The products of such changes are highly irritating to the delicate organs and the vomiting and diarrhœa set up by a little sour milk or other food are notorious.

To sum up, then, the following rules should be strictly observed in the diet of infants.

1. The food should contain the various alimentary substances in the proportion which obtains in human milk.

2. It should possess the antiscorbutic element.

3. It should contain at any rate a fair proportion of animal matter.

4. It should be in a form easily digested.

5. It should be fresh and sound, free from all taint of acidity or decomposition.

In the case of invalids, again, the supply of food and its character have powerful influence for good and evil upon the course of the disease, and may turn the scale in favour of life or death. But in this instance general rules cannot be laid down with the same precision as with infants. Perhaps two or three broad simple precepts may be allowed.

First, that the food should be in a digestible form.

Secondly, that it should be as far as possible palatable and tempting to appetite; and thus the art of cookery comes as a powerful aid in the preparation of an invalid's diet. For the appetite and digestion of the feeble and diseased are more or less impaired.

Thirdly, it must contain the antiscorbutic element.

We may go even a little further, and affirm that a certain amount of nitrogenous matter is also essential, for we know that without it strength and vitality infallibly decline. But

beyond this the laws of diet for the sick necessarily vary widely, according to the disease, and the condition of the patient. In this relation, the proverb that what is one man's meat is another man's poison is strikingly true.

The abundance of nitrogenous matter, so beneficial to a patient worn down by fever or exhaustion, is deleterious to the man with plethora, or gout, or kidney disease. The starch and sugar, so feeding to lean and ill-nourished persons, are highly injurious to the diabetic. The fat, so useful to the consumptive and to the rachitic, is a source of injury and discomfort to the bilious and dyspeptic. And dyspeptics even differ greatly in their power of digesting different kinds of food. The stomach of one can deal best with food in a liquid form, that of another with dry solids. Others, again, require the assistance of food already partly digested by being previously peptonised, by the aid of gastric and pancreatic juices. In some conditions it is advantageous that food should contain a certain amount of insoluble matter to stimulate the action of the intestine; in others again—as when there is obstruction of the bowels for instance, food should contain absolutely nothing which is not perfectly soluble, and will be absorbed, leaving no debris or residuum behind. Thus both the kind of nourishment, and the form in which it should be offered, have to be modified in various ways to meet the different needs and powers of the weakened or disordered body which it is designed to nourish. This adaptation of food to special conditions falls within the province of the physician, and forms one of the most delicate and important features of his art. The preparation of articles of nourishment suited to the varied requirements of disease is, however, a thing apart from medical practice, and is based upon principles sufficiently well defined. Thus the various meat teas, and essences, and extracts, represent nitrogenous aliment in a concentrated form, so that a large amount of this element can be given in small bulk and in a state easily digested and assimilated. Yet many of these essences are faulty, from containing a high proportion of

gelatine and what is called extractive (inferior nitrogenous matter), and little of the higher albuminate or proteid. The preparations of raw meat juices, however, contain almost all the albuminates of the flesh from which they are extracted. Farinaceous preparations contain the starchy elements in a finely divided state, and in many of them these constituents are rendered still further easy of digestion by malting, a process which partially converts them into dextrine and grape sugar. The special articles of diet for diabetes are preparations of vegetable substances, from which the elements of starch and sugar have been to a large extent removed. The difficulty in this case lies almost entirely with the farinaceous staples, that is, in supplying them free from the ingredients which the morbid digestive action of the diabetic person perversely converts into an unusable form of grape sugar.

On these points it is, however, unnecessary to speak further here. A full account of the properties, value, and defects of the various forms of infants' and invalids' food are given in full detail by Miss Wood in the following pages.

W. B. CHEADLE.

PART I.

FOOD OF INFANTS.

CHAPTER I.

ON THE PREVAILING MISTAKES IN FEEDING AN INFANT.

IN every enterprise it is essential to its success to make a good beginning; if the keel is well and scientifically laid the ship will rise up in its place, graceful and true; if the foundations are carefully planned and evenly dug the building will stand firm and secure through the storms; if the woodman rear the sapling in its natural way it will grow a fine stately tree—if the mother bring up her babe in accordance with the laws of Nature it will develop into a healthy child. But, alas! these little sensitive humanities have, in nine cases out of ten, a worse chance of success than the puppies and kittens who scramble up together with them into existence, and they start in the race of life terribly handicapped by the results of others' follies. The dogs and cats have at least an unerring instinct to guide them in their maternal duties, and if left to themselves would bring up their offspring in accordance with great natural laws; but the human mothers, for they are the great offenders, separated from the beasts by the higher gift of reason, pervert that which God gave them as a guide through the intricacies of life, into a means for outraging His laws. Ah! if it were only possible to arouse the mothers to take a right view of their great and holy duties—these young lives are given into their hands to make or mar as they please; and, guided by selfish considerations, they will more

often mar than make. It is not only those who inherit generations of ignorance and wrongdoing, and whose faults are more from lack of knowledge than wilfulness; but those who, because of a higher education, should know better, yet with their eyes open bring up their infants in reckless disregard of the laws of life; perhaps trusting, oh! how vainly, to a beneficent nature to undo their mistakes.

The laws of Nature cannot be set aside; God has fixed them by an irreversible decree; and, though for a time the offender may seem to escape, sooner or later he will suffer for his neglect of them. There are certain penalties attached to the disregard of them, and they are as certain to fall as the sun is to rise in the morning or set in the evening. It is a sad sight to see the poor mothers, themselves already debilitated and diseased by early errors in their infant life, with infants in their arms, and to know that those mothers will perpetuate those very mistakes of which they feel the effects so painfully in themselves, sometimes because they wish to save themselves trouble, sometimes from the erroneous idea that they can alter the laws of their being. With a kind of mute resignation, touching because of its very helplessness, they will resign themselves to bring up "afflicted" children, when if they would but brace themselves to the task, these very "afflicted" little ones might become strong and healthy children.

The material out of which the young life is to be developed must be given to the infant by the mother in its food, and therefore it is essential that the food should be of the right kind, be prepared in the right way, and given at the right time.

There are two leading errors in the feeding of infants that work sad mischief in their young lives—the first is Improper Food—the second, Improper Feeding.

To understand the first error, we must consider what the food has to do; and how that food is best fitted for its functions.

When the babe is born into the world, it is perfect in its being; each organ is there fitted for its function, each limb

endowed with movement and utility; the whole man is there contained in that little form, but the whole has to be developed, and the material that will form the most important factor in that development is food. The babe's life in those early days should alternate between eating and sleeping, and the success with which it will perform these important actions will mainly depend upon the suitability of its food. Out of the food supply the babe has to find the earthy matter to harden the gristly limbs into bone; it has to find the fat to clothe its flesh, the material to enrich the blood, the tissues to build up the internal organs, the fibres to develop the muscles, and beyond that, the heat that nourishes its feeble life into vitality. It receives the food into its stomach, and during the period of rest elaborates from these materials the supply for its body. The food supply of an infant has, bulk for bulk, to do more work than the aliment of an adult; for it has not only to replace waste and maintain life, but it has to give out material for developing the frame. The growth of an infant in the first year of its life is out of all proportion to its subsequent development, and this is the outcome of its food. This growth is aided or retarded by the air that it breathes, and by the amount of rest that it is allowed; but even under very disadvantageous circumstances it grows more rapidly in its first year than at any subsequent period of its life. A healthy baby at its birth should weigh from 8 to 9 lbs.; at the end of its first year it has more than doubled that weight.

There is only one food provided by nature for infants during the early months of their lives, and that is milk; the mother, if in a healthy natural habit of body, is provided with this food on the advent of her babe into the world, and it is one of her holiest duties to supply that food to the little helpless life dependent upon her. This fluid contains in itself everything that is needed for the development of the human frame; it is all held in solution, making it easy of digestion and of assimilation.

The analysis of milk shows that it contains Sugar,

Butter, Caseine, Mineral Salts, Water—the combination varying in the milk of different animals, but all of them containing these materials, and out of them are built up the tissues and organs of the body. The sugar, and butter or fat, are the heat-generating products, the caseine or cheese are the flesh-producing elements, and the mineral salts enter largely into the bone and blood of the frame. These four elements are introduced into the babe's stomach in the form of milk, and this is Nature's standard of food until the appearance of the first teeth is a signal for an increased diet ; all deviations, therefore, from this standard must be wrong.

Our present artificial way of living has, unfortunately, introduced many deviations from this standard. They may be either primary deviations, that is, the quality of the food entirely altered ; or they may be secondary deviations, that is, foreign elements introduced into the milk through the agency of the mother. Among the most glaring deviations from the standard food is that of feeding an infant beyond its digestive powers. A mother is sometimes so mistaken as to think that milk is not sufficient, and so she endeavours to make the babe's diet more like her own, and the tender, long-suffering stomach is choked with food off her table, tea, bread, a piece of meat or dried fish to suck, beer, sometimes, alas gin! In the nurseries of the more well-to-do this table of fare is represented by some of the varied foods and infants' biscuits offered to the public, or perhaps some of the rich dishes prepared for the master's table—in both cases the results are the same, an impaired digestion, disordered bowels and a weakened frame, besides the present evil of a fractious, restless child.

The second deviation is the admixture of foreign elements in the milk, through the agency of the mother. Milk is perhaps the most sensitive of all forms of food, and absorbs into itself the surrounding atmosphere, or any products of the food of the animal in which it is secreted—the turnipy taste in butter is familiar to all—the richness of its qualities will also depend upon the generous and

healthy diet out of which it is made. The poor mother will mix gin, beer, and such like, with the milk on which she nourishes her offspring; the rich mother will mix wines, spirits, highly-spiced and indigestible foods, tea and coffee, with the food of her babe; again with the same result, a weakened digestion and an impaired constitution. A nursing mother should be careful of what she eats before suckling her babe. It is wrong to nurse the babe after eating a rich, stimulating meal, after taking wine or spirits, or after returning from a heated, excited dance, jaded and tired. If the mother feels that her milk does not satisfy the infant, she should drink a glass of good milk half-an-hour before nursing.

As the infant passes into the first stage of dentition, its diet will require to be increased; but it must still follow the simple lines laid down for it by nature, and consume milk as the basis of its food, though being gradually weaned from the mother. The next element that should be given to the child is some form of wheat-flour, of which there are many good preparations offered to the public; one meal a day at first substituted for the breast-milk, until by the time the infant is ten months old it is entirely weaned. It may then have a small portion of additional animal food, in the form of beef-tea, broth, or good gravy; and by the time it is twelve months, may have egg or milk pudding. At eighteen months a more generous diet of animal food may be given, meat scraped or pounded once daily.

On the question of giving additional animal food before twelve months of age there is a difference of opinion; and as children are not all framed alike, there may be room for this divergence—find out what suits the child best and let him have it, only do not start with a theory to which the little stomach is to be stretched or narrowed.

Improper feeding consists, in feeding at irregular times with improper quantities, in an improper manner.

Few practices can bring more discomfort and weariness on mother and babe than the practice of feeding the infant whenever it cries. This has its origin in maternal selfishness,

for the mother cannot put up with the cry of her child, forgetting that a healthy cry is a useful means of expanding the lungs, filling them with air and so purifying the blood. A little firmness and discretion in the first few weeks of the little one's life, will be amply repaid by the content and good temper of the babe, and the rest and peace to the mother. As a rule the shortest interval between the feeding times should be two hours; in the case of a healthy infant and good milk this interval may be extended to three hours with advantage. If the mother is always draining away her breast-milk, the organ has no time to secrete the fluid required, and so the supply becomes thin and unsatisfying, and the mother becomes weak and irritable. If the baby is always being fed whenever it cries, the stomach is overloaded, it has not that period of rest that is necessary for the due performance of its function, its action becomes weakened though increased, a habit of vomiting is induced, and the bowels, in sympathy coming to its aid, become disordered. The moral effect upon the child is, that it becomes quite exacting on its mother, and wearies her and itself with its incessant alternations of crying and feeding. At night the interval of feeding after the first three months may be doubled, so that both may rest well, and the infant will not cry until taken up, but when it awakes soon sink to sleep again, ready to enjoy its morning meal with a healthy appetite. Babies may be brought into habits as regular as a clock, with a little patience and forbearance at the outset, and the poor mothers who have to work and tend their infants would be much the gainers by pursuing this plan.

Feeding with improper quantities is so much part of the former paragraph, that the two can hardly be considered apart. The result of feeding at irregular times is that the babe takes either too much or too little, for it has not a healthy standard of requirement by which to regulate its supplies.

The quantity of each feed will vary with the age of the child; at first it will not take more than two ounces, which is about the quantity secreted by each breast; but after three

months the quantity may be increased to four ounces, so that in the twenty-four hours the child should take about one-and-a-half pints. If the infant has to be brought up by hand, the same quantities should be given, and only that quantity be put in the bottle, which must be taken away when emptied, or the child sucks air, or stale food into its mouth. Let the food be made fresh each time, for the milk will readily decompose if left standing.

Nature has provided us with a standard for the manner of feeding; she prepares her meal fresh each time, and only in the quantity required, and she serves it up in a cleanly style. It is unfortunately a standard not observed; for either the mother allows herself to drift into slatternly habits and thus contaminates her supply of food, or, if she uses a bottle, that is allowed to get stale and fusty, either for want of proper washing, or from the lazy habit of leaving the food in it between the feeding times. Laziness and ignorance have much to answer for in the maladies of young children, and there is much excuse for a poor overworked mother, who has the cares of providing the money as well as of rearing the children on her hands; but still the time spent upon these little details, which seem of no importance, will be well repaid in the end, by the quiet orderly habits of the little one, which will allow of the work of the house being done in the intervals, when the babe is either sleeping or enjoying a well-earned kick on the floor, and it is to the interest of every mother to grasp this truth.

When the preparation of the infant's food is the duty of the nurse, the mother must not only teach the imperative necessity of cleanliness, but she must satisfy herself by personal inspection that her orders are carried out; and as it is a mother's holiest duty to nourish her infant, so if it is her misfortune to be unable to perform her function, she should do the next best thing, and see that all is done as it should be. When a bottle is used, the best shape is the old-fashioned boat shape, with a calf's or india-rubber teat; when the bottle is not in use it should be kept in pure

water, and after each feed it must be rinsed out with warm water with a little soda in it, thoroughly cleansed from every particle of food, the teat taken off, cleaned, and kept in the water until wanted. Many mothers and nurses have a decided preference for the more modern bottle with the india-rubber tube, a very mischievous invention, and answerable for many infantile ailments, because it is so difficult, nay, almost impossible, to make perfectly clean. Any particle of milk clinging about it will turn sour, and infect the fresh contents of the bottle, disarranging the child's stomach and taxing its bowels, so that it had better be discarded; still, as such a reform is impossible, more time must be given to making it quite clean. Connected with this bottle, is the bad plan adopted by some mothers of giving the baby the tube and teat alone to suck at, to keep it quiet; this is only a miserable travesty of feeding, it induces a bad habit of sucking, and with it the child takes in a great deal of air into its stomach. If a baby is regularly fed with nature's diet, it will be comfortable and happy between the feeding times, and require no such petty devices to cheat it into propriety.

CHAPTER II.

THE RESULTS OF THESE MISTAKES.

EVERY mother should have some knowledge, even though it be slight, of her infant's physical nature, so that she may understand in a rational manner how to feed it, and how to avoid or correct the minor disorders that may attack it, through its food. Such a standard of knowledge is not by any means attained by women before entering the married state, their experience is more the result of experiment on the firstborn. Were a class of mothers found, and put through an elementary catechism, as to the internal arrangements of their babes, they would be found to have very vague and contradictory ideas of the functions of the stomach or the digestive tract—the first is probably a bag that must be kept filled, and the latter a long tube that distributes its contents about like a pipe; as to the peculiar provision designed for the digestion and assimilation of the food, of this they would not have the vaguest idea.

Inside that minute frame there is the most elaborate chemical works ever devised, and there is a very perfect mechanism contrived for the purpose of distributing the nutritive materials wherever they are wanted. The digestive apparatus begins with the lips, and ends at the anus; it is, in fact, a long tube, of unequal dimensions, and with varying functions. It is lined with a secreting membrane called the mucous membrane, which keeps it well lubricated throughout its entire length, and in all its folds. The condition of this membrane is shown on the tongue and inner surface of the mouth; in health, it should look clean, of a healthy pink tone, and moist; but it is very sympathetic with the state of the stomach, and betrays disorder in that organ, by a furred dirty appearance, or by a crop of

minute pustules on its surface, called thrush; in very serious ailments, these grow into small ulcers. This state of mouth and tongue is one of the results of unhealthy and careless feeding, is caused mainly by sour milk, or by dirty bottles.

The tongue, fauces and cheeks are all brought into play in the act of sucking, and from the glands is secreted the saliva that, mixing with the food, prepares it to go down past the throat or pharynx into the œsophagus, which is the long narrow tube that connects the mouth and stomach. The stomach is a membranous bag, in reality a widening out of the digestive tube, in an infant, of the size of an egg-cup; it has two openings, the one to admit the food, the cardiac orifice, and the other to allow the food to pass into the intestines, the pylorus; during the act of digestion the stomach pours out a fluid called the gastric juice, which acts chemically upon the food contained in the stomach, and macerates and dissolves it; its action is aided by a slow movement of the stomach, by which the food is turned in all directions, and the mass thus brought into contact with the gastric juice, which is a powerful acid. The pyloric end of the stomach opens into the intestines or bowels, which are a continuation of the digestive tract, and consist of a long tube coiled inside the abdomen or belly, the lower end of which terminates at the anus, through which the waste matter is expelled from the body. This long tube is lined all through its length with the same secreting membrane, and has besides, a complicated apparatus of blood vessels, which select and distribute the nutriment to every organ of the body. There are two other organs of the body which assist in the process of digestion, viz., the liver, which secretes a fluid called bile, and the pancreas, which secretes the pancreatic juice; both these fluids act upon the food on its passage through the intestines. The intestines have an automatic action, like the progress of a worm along the ground, by which the mass during the process of digestion is carried along their whole length.

In the process of digestion the food is first of all moistened with the saliva, and then received into the stomach,

where it is acted upon by the gastric juice, which first separates the milk into curds, and then mixes it into a third substance, known as *chyme;* in this state it is passed into the first bowel, where it is subjected to the action of the pancreatic juice and bile. These act especially upon the sugar and fat, and the whole material is converted into *chyle*, a highly nutritive fluid in a state to nourish the various organs of the body by being taken up by the vessels.

The entrance to the intestines is jealously guarded by a door, the pylorus, which refuses to pass into the bowel any ill-digested or crude material ; so sensitive is this opening that the presence of a hard unyielding substance is refused passage, and is sent back again to the stomach to be subjected to a further action of the gastric juice, and the accidental passing of any such material gives rise to the well-known pain in the stomach. In the young infant there is due provision for the performance of these functions, only in a minute delicate manner, and so sensitive is the balance between cause and effect, that a small particle of sour food will suffice to cause disturbance along the whole digestive track.

The stomach and its appendages being fitted only for the duty natural to them, it must follow that an unnatural demand being made on their functions will lead to a condition of disease. If any food not milk is given to the babe the stomach is at once over-taxed, it endeavours to meet the demand made upon it, and so becomes over-active ; the result of this is permanently to weaken the organ, the gastric juice becomes altered in quality, so that the food committed to the stomach is not duly prepared to nourish the body. Nature has provided herself with a means of ejecting unsuitable food, or food in excess, by the rough and ready mode of vomiting ; it is at once her protest and remonstrance, but though of all means the least harmful, still it induces an irritable habit of stomach, and may be made use of too often—as the foundation of habits, even physical habits, is laid in infancy, and the digestive organs

may be brought into good or bad order by careful and judicious training. If we think for one moment it must be obvious that the stomach of a wee babe cannot dispose of the same food as an adult, and therefore if it is required to extract nourishment out of what is beyond its capacity, that it must be permanently weakened or injured. How many martyrs to indigestion would be able to trace the beginning of their trouble to injudicious feeding, if only their recollection carried them back so far.

These mischiefs extend to the bowels. The stomach having done its little best to macerate and dissolve the unwise diet given to it, is forced to pass on some of the material ill-digested into the intestines; these organs, jealous of the integrity of their charge, pass on the intruder with the greatest haste, to the manifest discomfort of the poor infant, who lies with legs drawn up, and belly tense, uttering restless cries of pain, until an attack of diarrhœa puts an end for the time, to its sufferings. The undue action of the bowels has left its mark behind, in an inflamed, irritable condition of the canal, and in a starved condition of the organs that are crying out for nourishment. The poor little babe becomes thinner and thinner, and the mistaken mother, in her efforts to fatten her child by increasing its food, makes bad worse. There is all the difference possible between a child nursed, even partially, and one brought up by hand on improper food; the one is contented, comfortable and plump, the other is fretful, restless, irritable, and flabby—perhaps it is not saying too much to hint at the probable origin of a bad temper in the stomach! but it is quite certain that a peevish, irritable baby is so, because its food disagrees with it.

Next in importance in its mischievous results is *irregular* feeding: irregular in quantity and in interval. The functions of the body are most efficiently performed when due regard is paid to the need of rest even in organs out of sight; too little rest enfeebles the action, we know this of our own experience; a prolonged effort whether mental or physical brings on exhaustion, and a longer

period of repose is necessary to restore the tone—if the excessive action is persisted in, even when the organ is crying out for rest, it becomes permanently enfeebled and ultimately breaks down.

As the stomach is not simply a bag, filled and emptied by taking food; but is a muscular organ, with an appropriate action, both muscular and secretive, brought into play by the stimulus of receiving food, it must follow that it requires an interval of rest to alternate with its period of action. Neither does the stomach simply receive food and pass it on, the process of digestion is one requiring time. The contents of the stomach have all in turn to be subjected to the action of the gastric juice, before they can be passed on into the bowel; and if the mother is always feeding her baby when it cries, too much food is kept in the stomach and it is not properly digested; moreover, the organ becomes fatigued and unfitted for its work; it has no period of rest, and is obliged to do its work in a hurried, imperfect manner. One meal should be entirely disposed of before the next is given.

It is not healthy to give food between meals, it spoils the appetite, and brings the child into greedy habits. At night the period of rest given to the stomach must be longer, and except the child is ill, it should not be awakened to be fed. Nurses in hospitals get into the bad habit of awaking comparatively healthy children for feeding, forgetting that sleep is meat and drink to the infant. On the other hand, irregular intervals are hurtful, the rhythmical action of activity and rest is interrupted, the appetite unsatisfied at its usual time begins to feed on itself, and when the meal is given it is not in a healthy state to enjoy it. The temper also becomes fretful and impatient, the healthy sensation of hunger passes into that of exhaustion, affecting not only the stomach but all the organs of the body; they languish for their supply of nourishment—"too tired to eat" may be baby's condition as well as its mother's.

The quantity given must be regulated by the size of

the receptacle. In rest the stomach is about the size of an egg-cup ; it is elastic, but only to a certain extent, and if tightened out like a drum, cannot properly perform its function of moving the food about, and also in course of time it loses some of its elasticity and tone. The infant suffers great discomfort from an over-distended stomach, which it can only relieve by vomiting, and as it has this remedy at hand the evil is sooner got rid of, and its ill-effects minimised. Still this is no reason for continuing the practice ; it is a wiser course that the babe should leave the breast before quite satisfied than that it should be fed until it vomits ; the result in the long run must be an irritable stomach and flatulency.

The infant's condition is the best indication of its successful feeding. A rationally-fed baby will be happy and comfortable ; its face will look at rest ; it will smile and laugh upon the world with the inconsequence of ignorance ; it will be a matter of indifference whether it is in the arms or in the cot, and it will learn patience and self-control. Yes, it is not too early to teach the little one that lesson, that though a person of great importance, yet it must wait sometimes. The habit of crying for a thing, and crying until it has what it cries for, is begun in the earliest infancy ; and in giving in to that human weakness, the mother is preparing a rod for her own back, which will end in sorrow and bitter self-reproach.

"I'ceamed, and I'ceamed, and I'ceamed till I got it," was the triumphant utterance of a little mite, of a little over two years, who had so early learnt her guardian's weak point ; and experience teaches us that the "ceaming" will be carried on in a modified form through life, until some bitter discipline is mercifully sent to correct the over-indulgence of early years. Children, even at this tender age, are very knowing, and quickly judge if they are going to be masters. A young thing was heard muttering to herself one day, "It's no good my crying now, Aunt Janey doesn't mind it," and the result of Aunt Janey's indifference was very soon evident in the more contented happy child-

life. It is *most* mistaken kindness to attend to the baby's cries, unless there is a cause for them, and that the mother will soon know. A passing nod, or word, and smile will satisfy it with notice; it does not want rocking, or thumping, or shaking, or being fidgeted at, tired out itself and its nurse likewise, by going through a series of gymnastic performances.

CHAPTER III.

WHAT CONSTITUTES RATIONAL FEEDING.

In other words, how may an infant be so fed that his body shall develop and his health be maintained in this the first stage of his existence?

It will be necessary first to understand what purposes food subserves in the body, and how those ends are attained by the appropriate diet of infants.

When the babe begins its independent existence, it has to find the materials for its development in the food given to it ; it has to grow as well as to live ; in other words, it has to maintain its force and build up its frame. The body is a wonderful piece of mechanism, capable of movement, progression, development, repair, self-adjustment and self-feeding. It may be likened to an engine with cranks, levers, wheels, pulleys, etc., having in it a boiler, fire, and force-pump ; this machine once set going never stops until it is finally taken down and put in the grave ; the repair, feeding, stoking and supply of new material is all continued whilst it is working and is part of its working. It is not only a mechanism, but it contains the intelligence to direct, control, and regulate the mechanism, and the laboratory to prepare the fuel that gives it force. Such is the babe and such is the man, "fearfully and wonderfully made ;" the highest order in creation, designed to expound the Maker's glory and wisdom. In all engines there is a motive-power, supplied by the steam generated primarily by the combustion of the fuel which gives out heat ; heat is converted into force, force into motion, motion into work done ; in the friction and daily wear and tear there is waste of material, which is replaced by man's agency, and the fuel is supplied

by the stoker; but the body is self-acting, self-feeding. The source of its energy is the food by which it is nourished; the materials out of which it constructs its mechanism, and repairs the waste, is the food; the heat that is necessary to maintain life is derived from the combustion of the food; the fluid that flows to every part, vitalizing all in its passage, draws its supply from the food; the mental effort that regulates the engine, and that goes forth out of itself to help others, derives its potentiality from the food; the food is the beginning and end of it all. In infancy the fuel has to be put on the fire by the mother or nurse, and it is no good their putting on what will not burn. The body requires a constant supply of suitable materials for its work, and these materials must be given in such a form that it may make best use of them. The materials required, are nitrogenous matter, hydrocarbons or fats, the carbo-hydrates or starches and sugars, and salts. The first class, the nitrogenous matter, is of the highest value; out of it the muscles and ingredients of all the important parts of the body have to be taken; it forms the essential agent of life and growth, there could be no existence or development without it. The hydrocarbons, or fats, are chiefly necessary to provide the heat, and therefore force, in all its forms; the fat also serves as a padding and clothing to keep the internal parts warm. The carbo-hydrates, or sugars, seem to supply light fuel, and to store themselves up as a reserve of force; the mineral salts enter into the composition of the blood, bones, and teeth. Lastly, there is the water, which acts as the universal solvent, and supplies moisture to the body. Though all these elements may be found around us, in the air we breathe, and the earth we walk on, still, we can make no use of them unless they are given in some compound form, and for the babe the best vehicle, and the only food that contains them all, is *milk*. They are found in varying proportions in different milks, and if it is necessary to bring up the infant by hand, the milk used must be brought as nearly as possible to resemble human milk.

COMPARATIVE ANALYSIS OF MILKS. (*Payen.*)

	Human.	Cows'.	Asses'.	Goats'.
Nitrogenous matter and insoluble salts	3·35	4·55	1·70	4·50
Fat (cream)	3·34	3·70	1·40	4·10
Lactine, sugar of milk, salts	3·77	5·35	6·40	5·80
Water	89·54	86·40	90·50	85·60
	100	100	100	100

MORE RECENT ANALYSIS BY GORUP BESANEZ.

	Human.	Cows'.
Nitrogenous matter—curd	3·924	5·404
Fatty element—cream	2·666	4·305
Carbo-hydrates—sugar of milk	4·364	4·037
Salts	0·138	0·548
Water	88·908	88·705
	100	100

There can be no doubt that the reasonable and natural way to bring up the child is at the breast, and it is a shame and a dishonour to motherhood to give up this duty for any reason short of imperative necessity; a mother who will face the self-denials necessary, and lead a rational healthy life, will reap the reward, in the comfort and health of her nursling; but, sad to say, there are some women who will take upon themselves the responsibilities of the married life, yet who are quite willing to sacrifice the wellbeing of those infants they have brought into the world to their selfish ease, or their false delicacy. Every woman who seeks the married state is taking upon herself duties, duties some of the highest that can devolve on any human being, and, in the sight of God, she is chargeable for the care, health, moral wellbeing of the babe she has asked from Him. With the infant that He gives, is also given the food which that infant will require, and His intention is that the mother shall nourish and cherish that babe in her bosom, and learn through self-denial and self-sacrifice the highest expression of love. The mother is henceforth to give her life to her young ones, she is to find her life in their life,

and she is to keep her health pure and wholesome for their sakes.

The next best resource is to have a wet-nurse, and if a healthy clean woman be selected, who has no constitutional taint, the babe should thrive. The selection of the wet-nurse should be intrusted to the medical adviser of the family, and he will seek for one whose child is about the age of the foster-child, and who has an ample supply of milk, then all will go well; this, however, is not always possible because of the expense.

If both the mother and the wet-nurse are out of the question, then the child must be fed by hand, and it is *most* important that this should be done rationally. Nature has given a standard diet to which she expects every one to conform, on pain of punishment, and chemical research has analysed that food, so that we may be able, as nearly as may be, to imitate it. Asses' milk is the next best substitute for human milk, the curd is light and easily digested; but it is often unattainable, except in large towns, and then it can only be the food of the rich, so that, as a rule, cow's milk has to be relied on. It may seem a very simple process, by the admixture of a little water, to bring cow's milk to the same standard as mother's milk, but this is not the only objection; the curd is heavier, and is much more likely to disagree with the stomach, and to disorder the bowels; this may be partially got over by boiling the milk, which causes the curd to coagulate in lighter masses, and it also protects the milk against infection. It has unfortunately been proved of late years, that milk can become the means of conveying the poisons of special fevers.

If cow's milk is to be used, it must be boiled and diluted with three parts of water, and have sugar added, in the proportion of a small tablespoonful to a pint. For the first month, the infant will require 1½ pint of diluted milk in the 24 hours; at three months, 2 pints, increasing to 3 pints by six months; it requires more in bulk because the cow's milk is weaker.

In spite of all care, it may be found that the cow's milk

does not agree, it may cause colic, vomiting and diarrhœa. There is yet another form in which it may be tried before finally abandoning it, and that is as condensed milk. Condensed milk has the advantage of being more easily digested, and of keeping perfectly fresh; it must be *freely* diluted, commencing with 1 teaspoonful to 30 of water, increasing the strength gradually, until at six months the full strength 1 in 10 is reached. It is a very serious mistake to give it too strong, under the erroneous idea that the child will get more food.

There are now two styles of condensed milk in the market, the sweetened and the unsweetened, the latter being sometimes preferred; but, after all said and done, these are unsatisfactory substitutes for the real thing, for however perfectly the component parts may be imitated, still there is always lacking the living principle, which in some mysterious manner conveys a virtue to substances mixed in life, which can never be equalled by artificial compounds.

If all kinds of milk absolutely disagree with the child, then some other food must be found that will suit the stomach, only milk should not be given up, until it has been submitted to a most patient, ingenious trial. Some parents are only too ready to say, "Oh! the milk is not sufficient, and so we are giving it something else," as though they were proud of the fact. The cats and dogs bring up fine healthy children on milk, and surely we can at least do as well as they.

It is very unwise to try the patent foods for an infant under six months of age; they are all too heavy, and are, besides, deficient in nitrogenous matter and fat; a child so fed will grow up rickety and unable to cope with acute disease; it will have deficient vitality and feeble powers of repair. The grand defect of all these foods is that they are vegetable and consist mainly of starch. Arrowroot and corn-flour are almost entirely deficient in nutritious qualities, they are of all foods the poorest; barley, sago, tapioca and rice are all open to the same objection, in a less degree;

oatmeal contains more nutrition than the above-mentioned grains, but it has also more indigestible matter. A very useful farinaceous preparation is fine entire wheat-flour, that prepared expressly for infants and invalids.

A very useful food, and a good vehicle for the conveyance of milk into an irritable stomach, is *bread jelly*,* only it must be made with great care, and many mothers object to it because of the trouble. Another excellent substitute for milk is whey, with three teaspoonfuls of boiled milk and one small teaspoonful of cream for each half bottle. Barley-water may be used, with the addition of cream, but to all these foods the quantity of milk must be gradually increased, as the stomach is able to bear it.

Many mothers are tempted to neglect their maternal duties, or to supplement them, by the lavish introduction of Patent Foods : "Perfect substitute for mother's milk ;" "excellent substitute for mother's milk." Now there is no such thing, it is a delusion ; not one of these foods can claim to be that ; they are valuable in their way, and in their proper place, but this is not their place. First of all, they are very deficient in fat, in which human milk is particularly rich ; secondly, they are overburdened with starch, which is not in human milk, and starch is not an element that can be used by the infant stomach, it taxes the digestive powers before it is converted into sugar and fat. This last objection has not the same weight, when speaking of malted foods, as the action of malting converts the starch into dextrine and sugar. Then to give the same relative nutritive value, the bulk of the food must be increased, which is a matter of importance in a small infant.

After the age of six or seven months, these foods are in their right place, as a supplement to mother's milk, but not as a substitute, and it is right that the public should know what place these foods occupy in the nourishment of their infants. The question of how to feed sickly children will be treated in a separate chapter, so that the medicinal and other remedies would be out of place here

* See Recipes at the end of Part II.

Enough has been said to draw attention to the fact that any food that is not milk, or that has not milk as its basis, is not a rational food for an infant.

We now reach the vexed point, how to proceed after the age of six months, and on this point there is much difference of opinion. One authority says, continue the animal food, in the stronger form of meat-extracts (broth, beef-tea, etc.); another says, by no means give the child animal food, other than milk, until after two years of age. Each authority will illustrate the precept by a successful specimen of a healthily fed child. What is a poor bewildered mother to do, who wishes to do all that is for the best for her offspring?

Practice is better than theory, any day, and mothers will often solve a question over which scientists are wrangling. The construction of the human frame shows that man is an omnivorous feeder; that in all individuals there is an idiosyncrasy that is the peculiar attribute of the individual. It is the egoism that separates the one from the other, the mysterious soul that stamps itself early in life on the infant, and that through life just makes each to differ we know not how, from his fellow. We have not all been turned out of one mould, framed to one pattern, and therefore it is quite out of the question to lay down a hard, fast rule of diet; what will suit one will not suit the other.

After the age of six months, when the formation and cutting of the teeth is marking a crisis in the child's history, and when the increased development is demanding increased nutrition, in some manner more food must be given, and the food that will agree best with the child is the food most suitable. The test of a suitable food must be looked for in the child's body, and in its general condition, and not be hunted up in books and treatises.

If the child sleeps quietly after its meals, or seems happy and at ease, if it is not troubled to a great extent with flatulency, if the bowels are opened easily twice a day or so, by a semi-solid motion, if its flesh feels firm and

plump, and its temper is good, then its food is agreeing with it, and it is deriving nourishment from it.

At this age another meal must be introduced once a day if the baby is at the breast, and the mother must use her own experience in the selection; any one of the standard foods may be used, according to directions; or biscuit-powder, or entire wheat-flour; if the child is being brought up by hand, one bottleful of the food may be substituted for the milk, and the milk itself should be given stronger, almost undiluted, if the stomach will bear it.

On no account should bread, as bread, be used as an article of food at this age; the ordinary wheaten bread of the household has been despoiled of many of the ingredients required by the infant, and in the process of baking the starch granules, and lactic acid, the product of fermentation, are fixed in the loaf in a highly indigestible form; it can only be used with safety in the form above mentioned as bread jelly. Arrowroot and corn-flour also must be struck off the diet-list; they are nearly pure starch, and as such are not nutritious. Children fed on these foods grow thin and feeble; they are voracious, in spite of the food they take, wasting daily more and more till they die.

Prepared barley, sago, tapioca, rice, are all for the same reason unsuitable foods, they are too starchy, and are only food because of the milk with which they are prepared.

Oatmeal is a valuable article of food, it is nutritious, and forms the staple diet of adult and child in the North country; it can hardly be used with advantage until the infant is eight or nine months old, as it taxes the digestion, but if it agrees with the child it may be continued with advantage as part of its diet.

If the child begins at this age with animal food, plus the milk, it should be given in the form of beef-tea, or broth, carefully prepared, half a teacupful a day at one time, gradually increased.

The appearance of the teeth in the gums is Nature's sign to the mother that she is preparing the child for an entire change in the manner of feeding, and the mother should

follow her lead by the gradual weaning of the child from the breast, so that by the age of twelve months it is entirely weaned. It is not right to make this change suddenly, it is a tax on both babe and nurse, nor on the other hand is it right to suckle the infant after the twelfth month, the infant requires more food than the mother's milk supplies, so that it becomes starved, rickety, delicate, ill-nourished, and the prolonged nursing exhausts the mother's strength, so that she is not able to secrete a nourishing fluid. It is one of those infringements of Nature's laws which bring their own punishment.

The child now being weaned, it may have an increased diet of animal food with advantage, in the shape of an egg, or some light custard pudding (the egg is more likely to agree if given in the form of a pudding), and some under-done meat, finely minced or shredded into a pulp, with gravy or beef-tea; porridge with treacle or milk, boiled bread and milk, or a plate of the entire wheat-flour. This is a good diet until the age of eighteen months, or two years. It is not a good plan to give bread and butter to so young a child, bread and milk is much more wholesome, and is a vehicle for a good supply of milk. Milk should form the child's drink until quite four or five years of age, when a variety may be made by the use of cocoa for one meal; tea and coffee are not proper for children, and *no* form of alcohol except by the order of a doctor.

Fruit well cooked and given in small quantities sweetened, is an important food, and one unhappily too much neglected in this country. It is not particularly nutritious, but it contains salts useful to the blood, and medicinally it acts as a purifier; it agrees very well with young children, and is readily eaten by them. The most wholesome time to give it is in the morning, at breakfast and for luncheon, not in the evening or at going to bed.

It is a very mischievous practice to let the child sit at the table with its elders, and be given a piece here and a piece there, with a little taste out of a glass; the food prepared for the elders is not fitting for the young stomach,

and moreover, it spoils the healthy interval that should elapse between each meal, and teaches the child greedy habits. The little taste out of the glass may be the foundation of that curse of man or woman's life, a craving for strong drinks. Many a drunkard unfortunately dates his love of drink from the glass at his father's table. Parents are not the only offenders, nurses and servants do the same to the impairment of the child's digestion.

The intervals of feeding may be increased to four hours after the age of eighteen months, and it is unwise in the case of a healthy child to anticipate the meals, the stomach then loses the interval of rest which it requires, in common with the other organs of the body, to fit it for its duties.

The whole of the above chapter may be summed up in a few words.

Find out what form of food suits the child's stomach best, and persevere with it ; do not start with theories to be reduced to practice, perhaps at the expense of the child's health—an exclusively animal diet, or a farinaceous diet, or a mixed diet surrounded with a hard and fast line, over which it is a matter of principle not to step; study the babe's nature, and found your practice upon the result of observation.

Avoid giving everything that you know to be unsuitable, which your common sense should point out to you ; let the food be simple, simply cooked and given at regular intervals, and not in too great a quantity at a time. Remember that it is only an elastic egg-cup you have to fill, and that after that egg-cup has emptied itself of its contents, it requires a period of rest to prepare for its next time of work. Also remember that the stomach will settle down to its work much better, if it is allowed to become accustomed to one style of feeding, than if perpetual experiments are being tried upon it, and that regularity in time and regularity in quantity are important factors in securing a healthy vigorous digestion.

This chapter must not conclude without a few words on prolonged nursing : It takes its rise from an erroneous idea

that, if the child be kept at the breast, it will hinder another pregnancy; in other words, the welfare of the child is to be sacrificed to an old wives' fable, and both mother and infant are to be weakened by continuing a process contrary to nature, and, for a visionary idea, are to make their lives a burden. If only parents would follow Nature's laws, and not intrude their ignorant thoughts, to mar the symmetry of her plan, our hospitals would be half empty; certainly, the patients that feed a children's ward are either victims of over-feeding, or under-feeding, or improper feeding. If the mother of a rickety child is cross-examined as to the previous history of her patient, she will be forced to own one of two things, either that the babe has been fed on the adult's food of the parent, or that it has been kept too long at the breast.

It stands to reason that a mother cannot go on for ever nourishing two lives, especially when it is very often a hard-working, half-fed striving parent, who is terribly handicapped in the race for life already; it is altogether a mistake on her part, and will cause evils to herself and her offspring, that a lifetime will not remedy. Every pang that a mother feels from her infant's teeth is a sharp reminder to her, that she is offending Nature's laws, and that she must mend her ways.

The process of weaning should be a gradual one, and may be commenced at the age of seven months, by substituting one meal of prepared food for the breast; it should be quite finished by the time the infant has reached the age of twelve months, and if it be done carefully, and as the child is able to bear, it will be got over very well.

CHAPTER IV.

FOOD FOR SICK BABES.

A SICKLY ailing child is a pitiful sight, appealing at once to our compassion and sympathy; its plaintive wail and questioning eyes, almost reproachful in their weariness, tired out ere life is half begun, missing its heritage of happiness and comfort, a partner in the suffering lot of humanity, often the victim of selfishness and ignorance, what is there in life half so sad? And when we add to this, the thought that that miserable start in life will dog its steps to the end, that scored upon the various organs in its body, will be permanent marks of bad feeding, and irrational food, it should surely make us most careful, most diligent to learn and follow out the natural mode of feeding. It is too much the habit to shake the head and talk sentimentally of "the poor little sufferers," or in pious tones to lament the sore affliction of God, in some wasted frame, when after all, God has had nothing to do with the mother's pig-headedness, which has turned a promising nursling into "a little sufferer." However, one half of mankind must always be occupied in rectifying the mistakes made by the other half, so it will be well to learn how to remedy these poor little stomachs, so as to do them the most good. It is a very difficult problem to grapple, how to feed a sickly child; the food is the cause of it, and the food is in fault, and yet food it must have, or it will die. The diseased organs are those that take part in digestion, they want rest, and yet rest they may not have; nothing but patience, love, and gentleness can deal with this problem. There are some people from whom a child will take food at once, and there are others who can only succeed after a battle; the one has tact and sympathy with

the child, the other probably thinks of herself first and the child last.

It will never do to start feeding a sick child in a hurry; the whole mind must be given to it, and every little dodge and wile brought into play, to get the food down without a battle. I have often heard a parent say, when leaving a patient, "He won't take a thing for me, he's not had a bit nor a sup for days." Perhaps a look into the mother's face is sufficient reply; though a mother, she has not learnt a mother's ways, and the over-indulgence of younger days is now showing its fruits. The little rebel soon learns that he is not to have his own way, and at last takes the necessary food without a murmur. The struggle in the first instance must be faced, and it is mistaken kindness to postpone it, under the idea that the child will become more tractable in time. The longer he feels his own strength, the more determined will he be in his evil ways, and the struggle, when it does come, for come it must, or the child will die, will be more exhausting to the patient, and trying to the nurse. I have known of one or two sad instances, in which a child's life has been sacrificed to this false and mistaken kindness. A child may be caught with guile, I do not mean anything approaching to falsehood or deceit; nothing can ever justify the smallest departure from truth, nor will it answer in the long run; but that artifice by which the patient's wayward attention is diverted from the disagreeable task, and advantage taken of that diversion to give the food or medicine.

The art of feeding does not only consist in giving nourishment, but in securing the child's willing co-operation in the process, when the good that the food is intended to do will be much enhanced by the will and appetite all acting in harmony. There is just all the difference between the dinner eaten by a sulky child in a bad temper, and that eaten with a healthy appetite in a good humour, and this is the reason why some babies thrive in the hands of one nurse, when surrounded by the same circumstances,

they remain stationary, or make but slow progress in the hands of another. The secret of this, as of all other good work, is, that the heart is in it. It has been said before, that the utmost cleanliness is necessary in the preparation of infants' food, and that dirty bottles or dirty habits are frequent causes of those stomach disturbances which destroy so many young lives. Experience has proved this to be very true. In the out-patient rooms of the Hospital for Sick Children, very careful instructions are given by the staff on these details of feeding, and the mothers are urged to discard the bottle and tube, in favour of the old-fashioned shape. Where they heed and practice this teaching, marked improvement in the condition of the patient follows.

The milk supply must be pure, and the vessels into which it is received must be pure and clean, chemically clean; if the means of the parent allow, it is wise to have the milk of one cow; but this is by no means essential, unless the infant is in a very delicate state.

The food should be prepared fresh each time, even during the night, and none should be left in the bottle, only that quantity being made that is required; the difficulty in the night may be met by keeping some water hot by the many machines that are provided for that purpose, when the heating of the food will take but a short time.

There are some infants who inherit a consumptive tendency from their parents, and this shows itself in intestinal irritation, in aggravated cases there is consumption of the bowels, and tuberculous disease of the mesenteric glands. The part played by these glands in the assimilation of food is very important, they receive the chyle when separated from the chyme, it passes through them and is conveyed to the receptaculum chyli, from whence, by means of the thoracic duct, it is taken to the heart to be oxygenated and distributed all over the body. The action of disease on these glands is to destroy their function, and the circulation being deprived of nutriment the child

becomes wasted and emaciated. In tubercular disease of the intestines there is inflammation, and the abdominal viscera become the seat of tubercular deposit, so that all along the tract there is diseased action, showing itself by pain, diarrhœa, impaired nutrition, and often vomiting.

It is easy to see that in such a condition of things it is of the first importance that the food given should be non-irritating, that it should be nourishing and not over stimulating, and that it should be easy of digestion. A very valuable article of food is raw meat, or raw meat-juice; if the former, the meat should be taken from the most fleshy part of the joint, it should be free from sinew or fat and perfectly sweet. It must first be minced either by a knife or in a machine, then pounded and finally rubbed through a hair sieve, a little raw sugar may be mixed in it, or some confection of the Pharmacopeia; 1½ to 2 oz. is a sufficient quantity for a meal. Children will take it readily, and if it suits them they thrive upon it. The meat-juice is extracted by soaking in water and pressure, either by tying the meat up in muslin and wringing the juice out, or by heavy weights—2 fl. oz. to 4 oz. is the right quantity. The juice will agree sometimes when the meat cannot be digested.

An artificial digestive is added to the milk when the stomach is intolerant of it, it is intended to imitate the action of the pancreatic secretion, and being mixed with the milk before the child takes it, makes it easier of digestion by beginning the process outside the body. Foods so treated are called peptonized food, and the agent is called pancreatine. There is no doubt that this is a useful adjunct in feeding delicate children; it may be added to all the foods mixed with milk, according to the directions given on each bottle. A rough and ready way is to put a teaspoonful in a tumbler of milk, when the milk may be drunk with advantage, when before it disagreed. Limewater in the proportion of ¼ to ⅓ of milk will aid in the digestion of the milk, when there is too

much acidity in the stomach, by correcting the acidity by its alkaline action.

Beef-tea is a very valuable form of animal food for the sick ; when *carefully* made it agrees with the stomach, and is both nourishing and stimulating. It is a mistake to give it to infants too strong, thinking by that means to convey more nourishment, the weakened stomach will not digest it, and the feeble powers being over-taxed only reach the limit of their endurance the sooner. In feeding these delicate little ones, it is of the greatest importance to have a just estimate of the powers of the infant stomach, so that the diet of an adult may not be prescribed for them, and then great anxiety felt when they do not take the quantity ordered. From 2 to $2\frac{1}{2}$ pints of fluid is as much as a child under two years of age can eat and dispose of, an infant of one year will take about $\frac{1}{2}$ a pint less.

If the irritability and weakness of the stomach indicate that so much fluid cannot be given, then it must have the same nourishment in a more concentrated form, in smaller quantities. It is highly injurious, and is mistaken kindness on the part of either mother or nurse, to think that because an essence or condensed food is used that they will best combat the disease by giving the same bulk as a more diffused food ; they are just undoing the good that this plan of feeding aimed at accomplishing. If beef-tea four times as strong as ordinary is prescribed, then only a fourth part is wanted to represent the same amount of nourishment ; if condensed milk is used then it requires to be diluted at least $\frac{1}{10}$ or $\frac{1}{7}$ to bring it to the standard of fresh milk.

The engine will only burn up a certain amount of fuel, and over and above this is waste either of power or material. The art of feeding a sick child is to find out what will agree best with it, and to give that food judiciously at regular intervals in regular quantities.

The form of food next in value to milk, as containing all that is necessary for building up and repairing the human

frame, is an egg, the white, the albumen, is almost identical with the curd or nitrogenous element in the milk; the terms nitrogenous and albumenoid are interchangeable; the yolk represents the hydro-carbons, and the mineral elements—out of the egg the young chick is formed, so that in its small bulk is all that is wanted to build up the frame of the young animal. An egg is easy of digestion, given either raw or lightly boiled; on egg and milk a delicate child may be nourished for a long time without the use of any other animal food, and well started on the road of life.

There are a variety of forms in which milk and egg may be combined; the most simple is that of custard pudding, either baked or boiled, which is simply the egg beaten up in the milk and solidified by heat.

In all forms of cooking an egg it should be done lightly, for when the white becomes quite set or hardened it is indigestible; a fried egg is perhaps the least wholesome form in which an egg can be cooked for a delicate stomach, and in the case of an infant would not be admissible. The egg beaten up thoroughly well in half-a-pint of milk is a wholesome, nourishing food, and is readily taken by a young child.

It is sometimes necessary to give the white only, when the stomach is very delicate; beaten up with two teaspoonsful of brandy and four of water with a little sugar to taste, it is very palatable and is liked by the child. The yolk treated in the same way can be given when in certain conditions of the internal organs a large proportion of albumen can not be assimilated. This latter is the brandy mixture of the Pharmacopeia without the cinnamon water, which is as a rule much disliked by patients; it gives the mixture a sickly taste.

When alcohol is indicated by the feeble condition of the infant, brandy is the only form in which it should be given; judiciously given and by medical advice, it is a most valuable medicine, especially in that wasting form of diarrhœa that rapidly pulls an infant down. Five

drops at a time, given in the raw meat-juice, or in the bottle, is a proper dose for a very young infant and will have an almost magical effect ; but the quantity of alcohol for an infant is a matter for the doctor to prescribe. Utmost attention must be paid to the food of an infant that is the subject of diarrhœa ; the acute state so quickly runs its course to death, or takes on a chronic form, that the first symptoms must be regarded and dealt with. It very often has its cause in some improper food or food carelessly prepared, which the bowel aims at clearing away, and if the effort ceases there no harm will be done, and perhaps the mother will be a little wiser for the lesson given.

It is when the food is seen in the motions in an ill-digested form, or when the stools are very relaxed, slimy, and streaked with blood, that it is to be looked at as a serious ailment. The food should be at once changed as it is doing no good, the form of milk altered, and the most minute examination made of the bottles, vessels, and all used in its preparation, the mode in which it is made, and the freshness of the preparation. It is in this disease that raw meat, or raw meat-juice, is so valuable, the qualities of the meat have not been altered or lost by cooking, nor has the fibrine been hardened, or the albumen coagulated, it is therefore more readily acted upon by the gastric and pancreatic fluids, and sent through the intestines in a bland, non-irritant form. The nourishing food restores tone to the weakened vessels, and the morbid action is arrested.

The same food is useful in those cases of marasmus or wasting caused by the mal-assimilation of food ; much patience and thought must be given to their feeding, and experiments tried until that form of food has been found which agrees with them best. Peptonized milk and peptonized gruel will generally be needed, as the stomach is too weak to secrete sufficient gastric juice to macerate the milk, and the coats are incapable of the churning action necessary for the process of digestion. If the stomach is fed with food beyond its digestive powers, the evil is increased, and the absorbent system of vessels having

insufficient and inefficient material given, feed upon the tissues of the body, and so the infant wastes; moreover the whole vital action becomes weakened and its processes depraved.

In these diseases our main reliance must be on peptonized milk, or gruel, and raw meat or its juice. Eggs cannot be assimilated in this condition of the digestive organs. The food must be given frequently, every one or two hours, in small quantities, as the stomach can bear it; if there is vomiting, then the stomach must have a rest.

When there is chronic diarrhœa, arrowroot may be used with advantage to thicken the milk or the beef-tea, as it induces constipation of the bowels, but it will not nourish the child, it is only a medicine.

When the opposite state of the bowels is the trouble, oatmeal may be given in the form of porridge, as it relaxes the bowels; beef-tea and raw eggs have also the same effect in a slighter degree. It is in all cases a wiser proceeding to endeavour to control the action of the bowels by the diet, than to have recourse to medicine which in the end weakens and impairs the natural action.

An excellent substitute for milk is whey, which is milk treated with rennet, so that the curd is separated, and the lighter part of the milk remains. The whey should be given mixed with three teaspoonfuls of boiled milk and one of cream, the quantity of milk being gradually increased as the stomach can bear it. Barley-water may be substituted for the whey with the addition of cream. The curd separated from the milk is a concentrated form of nourishment, useful where it is necessary to "feed up" the patient, and where there is a difficulty in swallowing fluids. Brandy mixes very well with it.

The malted foods will agree with children who are not able to digest and assimilate the curd of cow's milk, but they require the addition of cream to supply the lack of the fats and nitrogenous matter.

All highly seasoned and savoury foods are out of place in an infant's dietary, and most especially when the child

COMPARATIVE ANALYSES OF FOODS, PREPARED ACCORDING TO THE DIRECTIONS GIVEN WITH THEM.

Elements.	Standard food, Human milk.	Savory and Moore's Food.			Mellin's Food.		Neave's, Hard's, Ridge's		Nestle's Food.		
		Analysis.	Diluted 7 times with water.	Diluted in same proportion with cow's milk.	Malted Analysis.	Diluted ½ with cow's milk.	Analysis.	Diluted with water, ½ sugar and milk to be added.	Analysis.	Diluted with 10 parts of water.	
Nitrogenous matter . .	3·35	15·35	2·13	4·35	5·43	1·24	12·3	1·50	15·00	1·36	These analyses have been taken from those published in the *Medical Press and Circular*, 1872, or have been furnished by the proprietors.
Fat (cream) .	3·34	1·08	·15	·68	00·00	·46			5·00	·45	
Lactine (sugar of milk or grape sugar)	3·77	1·02	·14	·91	86·90	11·50			40·00	3·36	
Dextrine, or .		10·78	1·54	the same proportion					30·00	2·77	
Starch . . .		64·12	9·16				74·5	9·30			
Cellulose . .		1·36	·19		·22		3·6	0·40			
Salts . . .		1·92	·27		3·40	·22					
Ash . . .							1·16				
Water . . .	89·54	4·37	86·37	82·90	3·76	86·58	8·44	88·80	10·00	92·6	
			Deficient in nitrogen and fat, too much starch.	Nitrogen in excess, fat deficient.		Deficient in nitrogen and fat.		Deficient in nitrogen; the fat and sugar would be in the milk added "to taste."		Deficient in every element but sugar or lactine.	

inherits any constitutional delicacy, the food given cannot be too plain and wholesome, or too carefully prepared. If possible, the feeding of a delicate child and the preparation of its food should be the work of one person; the child takes better when it is handled by one accustomed hand who has learned its peculiarities and little fads, and the nurse will take a pride in her nursling if she feels that she is trusted, and can see the results of her care in the improved condition of the child.

PART II.

FOOD FOR INVALIDS.

CHAPTER I.

INVALIDS.

INVALIDS! What thoughts does that word call into being —what pictures does the imagination at once construct? The whole world seems full of invalids, beings whose life is a burden to them, who would give half their wealth to be eased of their wretchedness, who would barter their knowledge or fame for the careless life of the healthy man.

They may be met in a dreary procession across the continent of Europe, scattered up and down the sunny shores of the Mediterranean, steaming across the sea in pursuit of rest, camping on lovely spots to cheat their pain, all up and down the world among the haunts of men, life taking its sad tinge from their heritage of weakness.

There are invalids who are invalids because they have not enough food, and there are invalids who are such because they have too much food; there are invalids who have made themselves such, because of improper food, and there are invalids who are invalids because they will not eat proper food.

Food is frequently at the bottom of our ills and certainly of invalidism; that much-enduring, much-abused member of our bodies, the stomach, is answerable for ill-temper, for discontent, for fretfulness, for caprice, for ennui, and yet did we listen to its admonitions and heed its teachings, we should enjoy more peace, and find more happiness in our lives.

The success of half the water-cures and health resorts is based on this fact, for they associate with their strictly medi-

cal treatment a strict dietetic regimen, plain, wholesome and temperate, on which they insist as part of their scheme, knowing that the over-eating of the London season must be combated with the under-eating of the holiday season. It is a very irrational mode of treatment, but it is the only one that will restore the balance; far better would it be if the need for cure did not exist, but such self-denial is too much to look for in these enervating days.

There is a certain vow taken in early infancy that promises temperance in all fleshly appetites; unfortunately the meaning of this word has been narrowed down to an abstemious use of alcohol, thus ignoring its wide signification, which embraces all appetites and regulates the *menu* of the dinner-table as well as the cups of the inebriate.

This is one of the best prescriptions, it can be read and made up by every one for themselves.

It is quite certain that people eat too much; not only do they offend in the quantity of food taken, but in the variety of foods partaken of, so that at last the appetite becomes so jaded and satiated that it has to be tickled with highly spiced and novel dishes. Good were it for those invalids if they could be first set to work to earn their meal, and then be set down to a plain, nourishing dinner; it would taste richer to them than the most delicate dainties of the French *chef*, because served up with hunger.

There are offenders against this canon amongst the poor as well as the rich, and in their measure they have as many ways of gratifying the appetite; when the opportunity is given to them, they will indulge in most unwholesome, unsatisfying food, and as a rule the mode of cooking is anything but rational. It is above all things necessary that people should understand that the use of food is to provide force and energy for the duties of life, the gratifying of the palate being a secondary consideration, though with that wonderful adaptation of means to an end, our Creator has linked the satisfying of our appetite with the *duty* of sustaining life.

As over-feeding is to blame for many of the miseries of

invalids, so on the other hand is under-feeding. It is marvellous what a state of diseased appetite can be brought about by the imagination. We imagine that such and such an article of food disagrees with us, and the healthy functions of the stomach being much influenced through the will, the digestion becomes impaired, and to such an extent can this imagination be pushed that the stomach will at last vomit the food, and chronic vomiting will be induced. The sense of distaste for a meal, almost amounting to nausea—the result frequently of over-fatigue, or prolonged fasting, is familiar to each one of us, and we are conscious of an act of will and determination in the first instance to force the stomach to resume its functions.

The same sensation may come as the result of a distasteful occupation, or some sight that has disgusted or unnerved us, and it frequently attends the work of hospital nurses, or those who tend the sick. It must be striven manfully against, it is really a cry from exhausted nature, and the cure must be the taking of natural, healthy food, to prevent its becoming a fixed habit. It is likewise a form of hysteria not uncommon in young growing girls; it may spring from the foolish wish to appear interesting and delicate, or from the desire to check any approach to stoutness; but from whatever cause it may spring, the disease must be dealt with firmly and gently by the mother or guardian, the only way to nip the evil in the bud. In the same manner must a fanciful or wayward appetite be dealt with; but all coercion will fail of its object unless seconded by the intelligent will of the invalid.

I have seen young, growing girls treated as patients whose only disease was that they refused their food. The history received with them being, first, loss of appetite, then occasional vomiting, degenerating into a confirmed habit. It has been found that the disease could be quite conquered when separated from their injudicious friends, and dealt with kindly but firmly. Being one among a number, and without any prestige of illness attaching, nature soon again asserted her claim, and the reason for the malingering

vanished away. In a lesser degree this depraved appetite shows itself in extreme fancifulness and daintiness, nearly always the outcome of affectation. To a healthy stomach all food comes alike, and though in all cases there are likes and dislikes they need not be placed in the ascendant. Even where there is weakness and delicacy in the digestive organs, much of it may be overcome by ignoring and disciplining the organs to their duty. Like all our other functions, that of digestion is automatic, and to direct undue attention to it is at once to disturb its equilibrium. The stomach is a good servant but a bad master.

The effect that the mind has upon the process of digestion must be familiar to all who reason on cause and effect. A sudden mental shock will destroy all appetite for food, a disagreeable duty impending, a great anxiety or prolonged strain, a serious mental effort will disarrange the functions, and though the food may be taken from a sense of duty, there will be no enjoyment in the act, and the results obtained from it will be imperfect. So in like manner, the effect of any great mental excitement is to lead to a forgetfulness of the wants of the body, so that it may be carried past the usual time of feeding unheeded. The prolonged fasts of religious enthusiasts were all the result of such excitement.

All this goes to prove how intimate a connection exists between the mind and body, the latter being intended always as the servant to minister to the former; but it exacts the guerdon of all good service, viz., consideration and attention.

Invalidism, again, may follow from using injudicious food, and in this particular it is impossible to lay down any hard or fast line,—it is a true proverb, "that what is one man's meat is another man's poison," for what will suit one will not another, so there will always be room for vegetarians, and eaters of animal food, or followers of the Jewish rules of diet—in this matter there must be a large latitude for each individual; nor should we quarrel one with another because we do not all eat alike. In some

conditions of stomach and of living, a vegetable diet is most suitable, whilst for others the greater support furnished by animal food is required.

Indigestion is undoubtedly induced and increased by errors in diet, which might be rectified by careful attention to the indications given by the stomach, only as this often involves denial of favourite dishes it is not insisted on until that which might have been transitory becomes confirmed, and a miserable life succeeds over-indulgence.

Another fruitful cause of indigestion or dyspepsia is haste; in these busy days time represents money, and a hurried meal is swallowed with a preoccupied mind, to the detriment of the digestive powers. The food is sent down into the stomach half masticated, the stomach reacted upon by the general flurry is disconcerted in its action, and the resulting effect is dyspepsia. There is a certain dignity about the process of feeding that resents hurry and disturbance—it demands a time to itself, and asks recognition as an important factor in the process of life.

So far we have dealt with those mental forms of invalidism, or rather those which are intimately linked with mental habit; but there are other forms of weakness, which may spring either as the result of some prolonged illness, or from the irksomeness and monotony of an invalid's life, such as attends on the victims of some chronic joint affection.

These often lack the appetite for food, because of the absence of the stimulus of healthy change of scene, or of vigorous exercise; it is often a problem how to vary the diet so as to tickle the appetite. The same four walls, the same look out, the same unvarying routine, the day's monotony only broken by more or less pain, the absence of hope, the living for the sake of living, the feeling of uselessness, all these react upon and deaden the healthy bodily functions. Here is ample scope for thoughtful attention to the details of feeding.

What a sharp contrast there is in the lot of these invalids! all alike in weariness, languor and sorrow; but

some surrounded by all that wealth can buy and ingenuity devise to cheat their pain, and others without one mitigating circumstance to soften their lot; in the latter case learning the lesson of patience with but few hindrances, in the former clogged with many temptations, taught to be selfish, exacting, discontented, and where faith and patience triumph, triumphing out of many obstacles. If God made these sharp contrasts, He made them to give us opportunities of helping each other.

This form of invalid is difficult to feed, the appetite is capricious and morbid, a change of food is constantly needed, the whims of the patient are many, and sometimes may not be gratified because of danger to the health. It may be conciliatory, but it is not wise to consult the patient; in the first place, no one cares to know what they are going to have for dinner, it takes away from the surprise and anticipation; in the second, it arouses a spirit of perversity in the patient, who, wearied out with the ever-recurring question, "what would you fancy for dinner to-day?" will suggest something preposterous, and then be angry when refused. The course of food having been laid down by the medical authority, the details may be carried out by an intelligent nurse or attendant, who should aim at variety, combined with a wholesome style of cookery. All highly spiced and seasoned dishes should be out of the question; food may be made very palatable by care in flavouring and attention, and much thought may be bestowed upon the manner of serving. It should be sent up in a spotless manner, and in a small quantity, with pretty accessories, flowers, pretty china, etc., and when partaken of the tray be at once removed.

There are few things that betray the training of the nurse so much as her attention to these little niceties, and there are few things that so conduce to the comfort of the patient as attention to these small details; they are not unimportant, for anything that will tempt and encourage the appetite is worth thought. It is careless and untidy to leave remnants of food in a sick room, that which has been

handled and looked at by the patient is not tempting, and moreover the atmosphere of a sick room does not make a good larder. Unwashed cups, glasses and plates, are an unseemly litter, their accumulation can be so readily kept under. I have seen presumedly good nurses collect around them such an assemblage of cups, glasses, spoons, what not, that at last there was no clean vessel at hand, nor space to put it down out of hand. These may be counted as little fidgets, but they are very important fidgets in tending the sick.

It will be found a great help in tending an invalid to have a regular interval of time for the meals, and a regular quantity at those times—three hours is quite a sufficient interval for a weak stomach, and if this interval is observed a small quantity of food at a time can be digested.

Regularity, order, and method are very important when attending upon the invalids; this will save much friction of temper on both sides.

CHAPTER II.

ON DISEASE IN THE DIGESTIVE AND ASSIMILATIVE ORGANS.

AN intelligent arrangement of diet for invalids will presuppose an outline knowledge of the morbid physiological changes in the functions that call for this care and management. The process of healthy digestion has been briefly sketched, and a recollection of this will be of use in understanding wherein the disease lies.

The most common form of disturbance is indigestion, or *dyspepsia*. This may exist in a very mild form, or be of so serious a nature that the life is rendered a burden; there is every shade of degree between these two extremes. In whatever degree it exists, much attention must be given to the nature of the food, and to the manner of taking it.

Primarily in dyspepsia, the digestive functions are enfeebled in one part or other of the canal. It may be in the stomach, which does not secrete sufficient gastric juice to dissolve the nitrogenous elements of the food and convert them into peptones; this change must take place in the food before it can be absorbed into the blood. The weakness may be in the coats, which do not carry on the churning action necessary for the mechanical mixing of the food in its every particle with the gastric juice. When the stomach is inflamed, its disordered mucous membrane secretes mucus, which acts as a ferment and favours decomposition in the food; this sets free the gases of decomposition and causes flatulency ("the wind"), and the formation of lactic acid, a condition of acidity. The fault may be in the duodenum, the intestine below the stomach, the pylorus being the door of communication between the two. The semi-digested mass is here brought in contact

with the pancreatic and biliary juices, which act upon the fats and renders them fit for absorption, and the starches and sugars are converted into grape-sugar, in which form they are taken into the blood. The bile is secreted by the liver, and shares in the health or reverse of that organ; it may be either deficient in quantity or quality; in either case it does not re-act upon the contents of the intestines, by preparing them for assimilation.

No straight line of dietary can be laid down for dyspeptics, for as the causes of indigestion are various, the foods provided must meet those distinctions. Thus for some, animal food must be given in a liquid or semi-liquid form; whilst others, on the contrary, are disturbed by the presence of any large amount of fluid in the stomach; it seems to act as a solvent of the gastric juice, and impair its efficiency. It can be readily understood that the artificial digestion of food by the Liquor Pancreaticus must aid this enfeebled action, though an artificial combination can never equal the action of a living agent; nevertheless it is a very valuable auxiliary in the dieting of dyspepsia.

Fluid food is not always efficient as a stimulant to the secretion of the gastric juice, or to the mechanical action of the coats of the stomach; in this case food in small quantities in a solid form must be used.

Starches and fats are usually a source of discomfort, probably because the food remains too long in the feeble stomach, and fat is especially irritating with commencing decomposition; fatty matter of all kinds is unsuitable for dyspeptic invalids.

In the *Gouty* subject, the difficulty has changed its place from the stomach to the organs of assimilation; the nitrogenous matters in the food are digested, but the body does not burn them up in a healthy way, and dispose of the waste through the excretory organs. The used-up and worn-out nitrogenous tissues, and the overplus of the proteids or albuminoids, go wandering about the body, establishing themselves where they have no business, and so doing harm, instead of giving up their nutriment and

leaving when their work is done. When the nitrogenous matters are efficiently oxydised or burnt up, the waste is cast away in the form of urea through the kidneys ; but when this process is not satisfactory, uric acid is formed instead of urea. The uric acid will combine with soda and form urate of soda, which seems to be the chief irritating agent, setting up inflammation, and the other varied disorders of the gouty condition.

This imperfect assimilation may be caused by eating too much (unfortunately, a common form of disease), especially where the habits of life are sedentary ; or by eating of too rich, too highly nitrogenised foods, such as animal foods ; by drinking the stronger forms of wines and beers, and by taking sugar in large quantities. In all cases, gout more usually attacks sedentary, self-indulgent livers, than those of active habits and abstemious in their feeding.

To make the fire burn faster and fiercer will be one self-evident means of correcting this gouty tendency, as Abernethy did, when he made his gouty patients to dance on hot plates ; or, as in a less determined form, may be done by sensible people—making use of their limbs instead of those of other animals ; but this will not suffice in all cases. The evil must be combated by attention to diet. It will be necessary to reduce the amount of nitrogenous food (animal food) as far as may be consistent with the vital vigour, and limit the amount of sugar and of alcoholic drinks, as these interfere with the conversion of the proteids into fully oxydised urea.

Soups, broths, beef-teas, are not a suitable form of giving animal food to gouty subjects ; they contain a large quantity of waste nitrogenous matters ; but where gout is complicated by dyspepsia and feeble nutrition, they may be necessary.

In *Bright's Disease*, the organs chiefly in fault are the kidneys ; their work is to eliminate the waste after the oxydisation of the nitrogenous matter, and that caused by the wear and tear of the tissues, and to throw it out of the body. Failure in the performance of this function retains

the poisonous matters in the body, causing uræmia and uremic poisoning, very frequently ending in death from slow poisoning. Diet in this disease consists in a very spare use of nitrogenous foods, only as much as is really needed, and a large preponderance of vegetable food. Soups, broths, beef-teas, are not suitable in this disease, as they do not contain the most nutritious form of animal food, but instead, a large amount of degenerate nitrogenous matter which turns into very poisonous materials, and the body with inefficient kidneys has much difficulty in discharging these matters from it.

Diabetes is a disease in the assimilative process. It may be that the liver is chiefly in fault ; but in whatever organ the principal mischief lies, the result is a perverted action, so that the carbonaceous elements, and in some degree the albuminous elements also, instead of being converted into *glycogen*, a carbonaceous material properly prepared for use in the body, appear in the form of *glucose*, or grape-sugar, a form not adapted for the purpose, and which the body cannot make use of. On the kidneys is thrown the task of eliminating this sugar, which is found in the urine as diabetic sugar. The disease is attended with a morbid excess in the amount of urine, and very frequently with most painful thirst. Sugar is necessary in the laboratory of the body. It stands among the group of heat-producing elements ; and in the healthy subject it is so entirely absorbed into the blood and tissues, that it cannot be traced in the urine ; in diabetes, on the contrary, sugar is found in large quantities.

The object aimed at in the dietary is to exclude sugar and starch, the latter being converted into sugar during the progress of digestion, and especially into glucose, the objectionable form of sugar above mentioned. This strikes out farinaceous foods, especially wheaten bread, and all forms of grains, sweetened beers and spirits, and any cookery in which sugar is used. Fresh vegetables, excepting potatoes, are admissible ; fresh fruit, without sugar ; animal foods and butter. Milk must be taken sparingly ;

cream is permissible; tea, coffee, and cocoa, with cream and without sugar. The only substitute for bread or biscuits, is that made with gluten, which is the dough with the starch washed out, and bran bread. The diet is apt to become monotonous, particularly when the patient is young, and much of the success in perseverance will depend upon the cook and her skill in making variety. A free use of water is indicated, and may be indulged in with benefit; it supplies material to meet the drain of fluids that is going on, and, being the universal solvent, it materially aids in the process of assimilation.

Scurvy is a disease caused by imperfect nutrition, affecting the quality of the blood and the blood-vessels. The former becomes poor, watery, and deficient in vitalising power: the latter are weakened in their structure, the coats become feeble, the contents will ooze out, and as their contractile power fails, the circulation is languid and intermittent; the gums are spongy, the muscles soft, and there is extreme debility. The cause of this disorder is the absence of the organic salts from the diet. These salts are essential elements in the economy of life, and they are found largely in fresh vegetables and their equivalent must exist in milk. It is known that the deprivation of fresh vegetables, milk and fresh animal food—such as used to occur on a long sea-voyage, or in the case of prisoners and the very poor—gives rise to the scorbutic state, and that the disease may be combated by giving these articles freely, with milk and fresh animal food.

The development of scurvy is favoured by the use of salted meats, even though fresh vegetables form part of the diet, so that the change from salt meat to fresh, with little farinaceous food and abundance of fresh vegetables, will generally bring about a better state of things. In all cases it is necessary to take some form of vegetable acid, that of the lemon or lime being the most efficacious. The discovery of this latter specific, and the use of preserved and tinned meats and milk, has almost banished scurvy from the navy

Diet has much to do with skin-diseases. A fish diet, especially that of shell-fish, may cause *urticaria* or *nettle-rash;* tomatoes produce itching and an erythematous eruption; eggs are poison to some. *Eczema* may be much modified by an attention to the articles of food eaten, especially when it is the outcome of a gouty tendency. The *leprosy* of the present day may be favoured by a diet of fish, if not absolutely dependent on it. There is a skin-disease that occurs in Italy, called Italian leprosy, which is due to eating maize (Indian corn) when affected with a certain fungoid growth. In all these cases the cure lies in change of diet.

We are frail mortals at the best of times; but especially when the indulgence of the appetite is in question. The little boy at the school feast, who said that he might perhaps be able to eat more if he stood up, has his brothers and sisters of larger growth in every rank of society. No doubt that little man regretted the cake and jam that he had gorged, when the next morning found him with a headache and sickness, and all the other aches that come with repletion. He would long for the vigour and elasticity that usually came with his healthy meals; and let us hope that the remembrance of the day after the feast brought with it abstinence on the next occasion.

The Christian's vow of temperance, to "renounce the sinful lusts of the flesh," should be the safeguard against over-indulgence in the pleasures of the table, and, like all those good old precepts, will be found conducive to a long and happy life. There are few sights more pitiable than to see an old man or woman, victims of the diseases that spring from gluttony, tottering towards the end of life, with their hearts still set upon the indulgence of the palate; but with taste and smell almost gone, and nothing left to take the place of former joys.

The men who have left the deepest mark on their time, and who have done the best work, have always been abstemious, using food just for its right purpose, to keep the engine going.

CHAPTER III.

FOOD FOR INVALIDS.

IT is one of the provisions of Nature, that man should be obliged to seek the materials to maintain his being from the various compound substances around him. Though certain elements are required for his life, such as nitrogen hydrogen, carbon, &c., still he cannot make use of these in their elementary form ; they must be introduced into his body in combination with the natural substances in which they are found—in other words, he cannot supply himself with the nitrogen or hydrogen that are around him in large quantities in the air, but he must receive them in some organic compound.

In the laboratory of his body, man arranges these elements in quite a different form ; in some cases making entirely new combinations, such as fat out of sugar, and they pass through an infinity of changes whilst adapting themselves to his needs. They are all derived from the vegetable world, though in some cases they come to him secondarily, after having been incorporated into the body of another living animal. It is quite possible, and it has frequently been done, to resolve food into its primary elements, and then to put them in different bottles ; but it is quite certain that if a man were fed on the contents of these bottles he would die ; they lack that mysterious principle, *life*, which God only can give, and which unfortunately man can take in a moment, but can never restore.

The great divisions of food are into organic and inorganic substances, the latter being made up only of water and various saline principles. The organic must be divided into the nitrogenous and non-nitrogenous compounds, the non-nitrogenous into hydro-carbons (fats) and

carbo-hydrates (starches and sugars). The purpose of the former is to give the material out of which to build up and repair the body; the purpose of the latter, to serve as a source of heat, sometimes called the "calorifacients," or heat-makers; these latter also assist in the process of nutrition, but in a secondary way.

The only food that contains in itself all these compounds is milk; it is the type food, and is presented to man in a form at once ready for use. Next in importance are the various forms of animal food, and these will be nutritious according to the amount of albumen, fibrine, and caseine which they contain. Albumen is the white of an egg; it is a nitrogenous substance, and is found alike in the animal and vegetable world. In its common form it is a transparent, glairy fluid, tenacious in texture; it coagulates with heat, and is decomposed and neutralised by the action of alcohol.

Fibrine is the chief part of flesh, and is even more abundant in the vegetable than in the animal kingdom. It is found in the fibre of muscle, and exists in the blood; if the blood is stirred when fresh, with a stick, the fibrine will be found clinging to it like hairs.

Caseine is the curd of milk, and forms the basis of cheese; it may be found in the seeds of certain vegetables, such as peas, beans, lentils, all that are called leguminous.

Fish has its place among the animal foods, and, when considered as part of the diet of invalids, it occupies an important place. It is rich in nitrogenous matter, and those fish that have too much fat can be avoided, without limiting the choice too much. As a rule, white fish is more digestible than red fish; and of all fish the whiting may be regarded as the most delicate, tender, and easy of digestion.

After animal food, we have *Vegetable* food, of which there is almost infinite variety; but we must place the *Cereals* in the first place. These contain all the essential alimentary compounds; and first on the list stands wheat It is the most important, because it is made into bread, and a variety of useful compounds besides. All cereals have a

large proportion of starch, a substance which some stomachs find a difficulty in disposing of, and the presence of this starch in such a large proportion makes them less nutritious as a food than animal food. The want is supplied by the combination of milk. Baked flour and biscuit flour are both more digestible than uncooked flour; the heat breaks up the starch granules, and thus prepares them for the action of the digestive juices.

The finest wheat-flour is not so nutritious as the darker kinds, for the process of bolting removes some of the outer husk that contains the fibrine and phosphates; for this reason *true* brown-bread and wholemeal-bread are more nourishing than white bread. If our working population could be brought to see this, and would discard the white bread from their table, they would find the advantage in greater economy and in a healthier form of food.

Macaroni is an important preparation of wheat; it is made from the finest wheat, and has all the nutritive properties of wheat in a form easy of digestion. It is made from the Italian wheat, which is rich in gluten, and is a highly prized article of food in that country. In preparation it requires to be thoroughly softened in milk or gravy, as it is hard and close in texture.

Next to wheat stands *oats;* it contains less starch and more fat than wheat; it is deficient in gluten, and therefore cannot be made into bread; it is generally eaten as oat-cake or porridge. It is the staple food of Scotland and Northern countries; and if its nutritive value is to be gauged by the physique of the race fed upon it, it stands second to none in importance.

Rice is a valuable article of food in its right place; having a very large percentage of starch, it is insufficient alone to serve as nutriment; but associated with animal food, generally milk, it is of great use. The starch granule is easy of digestion, hence it agrees with some disordered states of the alimentary canal. "In diarrhœa and dysentery it agrees better than any other kind of solid food." (Pavy.) It is poor in nitrogen and fat.

The next class of vegetables are the Leguminous Seeds. The principal of them are *beans*, *peas*, and *lentils*. They are richer in nitrogenous matter than cereals, have less starch and are all deficient in fats; therefore it might be thought they would prove a more nutritious article of food than the grains; but experience has not proved this. They are not easy of digestion, and require some fatty or oily substance to combine with; still, as an article of food, they require more attention, and are very economical.

Chief among the edible roots is the *potato*, an almost universal vegetable; it contains a large amount of starch, and a small proportion of nitrogenous matter. As a food by itself, it is not sufficiently nutritious; but it is a wholesome and valuable addition to the diet of a healthy person, and is a necessity where there is a scorbutic tendency. The weak and dyspeptic stomach finds it objectionable, because of the large quantity of starch in it.

The green vegetables of the cabbage tribe are rich in nitrogenous matter; but they contain a large percentage of water; they also contain sulphur and ammonia, which is the cause of the disagreeable smell when cooking. They are a necessity in the treatment of scrofula, scurvy, and most of the eruptive skin-diseases. They are an article of food of much value from a medicinal point of view, and are not sufficiently prized by the poor.

The large variety of other vegetables will hardly claim a place as *necessities* of diet; but as welcome additions, giving variations, or for flavouring, they are useful and palatable. A diet in which there is a generous supply of vegetables is a healthy one.

Another of the useful products of the vegetable kingdom is *fruit*. In these, generally speaking, there is but little nutrition; but they are a very pleasant refreshing food, and contain many salts useful in the animal economy. A daily use of fruit, especially with the first meal, will often administer that amount of correction in the excretory functions, without the need of further medicine. Fresh fruit should always form a part of the diet of infants and

invalids. As a nation, we neglect this valuable article of diet ; it might with advantage be put upon the table at every meal.

The *Grape* has a value of its own ; it is not only a refreshing pleasant food, but it is also nutritious, from the quantity of grape-sugar which it contains ; and is a medicine, because of the bitartrate of potass, tartrate of lime and malic acid in it. The "Grape cure" and the "Raisin cure" have attracted a great deal of attention ; the grape or raisin is the chief factor in the treatment, combined with an exquisite climate and an open-air life. The *Raisin* is the grape dried, and in this form it is an important article in domestic consumption. It is highly nutritious and very palatable. The small dried grapes of Corinth, popularly known as "currants," are used in cookery, but they are not suitable as food for children or invalids ; they are highly indigestible, generally pass down the tract unaltered, and therefore cause irritation.

The juice of the grape comes to us as wine, that "which maketh glad the heart of man," and may be taken for the "stomach's sake." How far alcohol may form a part of our diet, or be used in the treatment of disease, it is not within the province of these pages to declare, as it cannot be classed among the nutritious foods ; its office is to stimulate, "to make glad the heart of men," and, like all useful servants and bad masters, it should be used with temperance and moderation. On this point let every man form his own judgment and rule of action, and allow others to differ from him without being placed outside of the pale of of salvation. Certainly in past days, our forefathers were too lavish in the use of alcohol ; and there are some now who must curse the first time it passed their lips ; but this is the abuse of one of God's good gifts to man.

There are still the farinaceous foods to be considered, such as *sago*, *tapioca*, *arrowroot*, &c. These foods contain a very large proportion of starch, and therefore require the use of some animal substance to give them the nitrogen they lack. They are generally mixed with milk, in the form

of puddings, or are used in soups. With milk they make a non-irritant, nutritious food for an invalid or for children. Taken alone, they are quite insufficient to support life. *Sugar* is a substance found largely in the vegetable world, and not so profusely in the animal. Its place is among the carbo-hydrates; it is extracted and stored up in the human frame to be converted into force as needed. It is readily digested, being very soluble; but in some conditions of the stomach it gives rise to acid fermentation. It is a necessity to young children, whose instinct teaches them to like it. Like all other good things, it must be taken with moderation.

All food includes in its category drinks, or beverages; and in many cases the action of the food is assisted by the mixture of some solvent. Some conditions of the stomach require the partaking of the solvent first, though this is an abnormal way of eating.

The universal solvent is *water*, which is found in large proportion in all solid food, and besides, is everywhere around. A pure copious supply of water is what every one ought to have as their birthright; but man has done his best to foul and curtail it. It constitutes the basis of all our drinks, and it is essential that it should be pure and be kept free from all contamination. It will absorb the noxious vapours in the atmosphere, and the decomposing substances in the earth; therefore, if stored for daily use, it should be in a covered non-porous cistern; or, if drawn from a well, the well should be deep and far removed from any source of contamination, such as drains, cesspools, or cattle-yards. It may be rendered chemically pure, by filtering through charcoal, boiling, or distilling.

The source of the water-supply is the rain, and rain-water, when obtained in the country, is absolutely pure. It is tasteless, from the absence of the salts of the earth, and is non-gaseous. Spring-water, which is rain-water returned through the earth, is the source of our drinking-supply, and its refreshing taste and sparkling look is obtained from the salts and gases with which it is charged.

Water, pure and simple, is a useful adjunct to the diet of invalids; and there are few illnesses in which, so long as it is absolutely pure, it may not be given with safety and benefit. It is an irrational practice to deny it to the sick; in illnesses in which there is fever, or those attended with profuse discharges, it is a necessity, as it supplies the fluid that is rapidly being dried up, or drained away from the body. A glass of pure water on rising in the morning, before food, is an effective aperient. Children as a rule take more water than adults.

Water in the form of *ice* is constantly used in the sick-room. It is palatable and refreshing, and is taken to check hæmorrhages; in fevers, diphtheria, and other throat-affections, it is decidedly useful as a local application and as a solvent.

Tea, coffee, and cocoa are the beverages most in use in the present day. Though different products, they are very similar in principle. Theine and caffeine are considered by chemists as almost identical; theobromine, the principle of cocoa, is the analogue of theine. Of these three drinks cocoa is the most nourishing, containing more fat and more gluten; it is more digestible, and has a less direct action on the nervous system. Tea and coffee both stimulate and revive the brain; they are almost a necessity in this bustling anxious life. Tea has the effect of restoring and refreshing the vital powers; coffee, of sustaining and exciting them; tea is more the beverage of the poor, coffee of the rich. Tea agrees better with a weak stomach than coffee, which is too rich and exciting, and tea will almost take the place of food and drink with the over-wrought and destitute; if the poor woman can only get her cup of tea she will be satisfied. Cocoa made with milk is an admirable breakfast drink; the best form for use is the nib crushed. This is the purest form of cocoa, being free from the foreign starchy matters with which it is often mixed.

In the form of *chocolate*, cocoa becomes a highly nutritious food, and is valuable for sustaining strength in the absence of other food, therefore it is useful on a long journey.

Chocolate is the best form of cocoa prepared with sugar.

Beer, in all its varieties is an infusion of malt and hops; it is a fermented liquor, the amount of alcohol being variable. It is a refreshing, exhilarating, nutritive drink, and in excess is an intoxicant. As a tonic, and as an aid to digestion, it is of value, especially the pale, bitter beers. The stouts are heavier, and, if taken in excess, induce a plethoric habit of body, accumulating imperfectly oxydised matter, uric acid, &c., leading to gouty complications. Beer in all cases must be taken in moderation; but there are some dyspeptics and those of a gouty tendency who cannot assimilate beer. Beer is especially the drink of the working classes.

In dealing with the food of invalids we must glance at the artificial compounds and scientific combinations which are prepared with the view either of aiding digestion, and of partially digesting the food before being eaten.

The principal of these are the preparations from meat,—the teas, broths, essences, extracts and jellies, malted foods, and peptonised foods.

The meat-preparations are prepared from fresh meat; are either well or badly made, according to the skill of the cook, and are *within* the compass of most people to get. The extracts and essences are also prepared by dealers, are hermetically sealed in tins, and may be either nourishing or delusive, according to the honesty of the maker. It is not difficult with some bones and cartilage, a little meat, and some colouring matter, to make a composition that will look very nutritious, as there is a popular idea that a stiff jelly is the sign of goodness. This is a delusion; some meat, rich and nutritious, will not set, as it is deficient in gelatinous matter, and this especially so when the meat is taken from the thick end of the leg; whilst other meat, if near the thin end, will set readily.

The aim or object of these meat-preparations is to convey the nutrition of animal food in form easy for digestion. This is done by extracting the virtue of the meat

by heat, either with or without the agency of water. The great mistake usually made in the ordinary style of cooking is that the process is too quick and violent. A cook is satisfied if she hears a great bubbling going on that she is making excellent beef-tea, whereas she is really spoiling it and wasting the material. Fast boiling hardens the albumen and precipitates it to the bottom, and it also hardens the fibre of the meat, so that it does not part with its juices into the water. If there is time, the meat should be first soaked for an hour, and then be put in a jar surrounded with hot water, and boiled very slowly, just simmering, for at least two hours. The meat must be *infused*, so as to extract all goodness possible. Beef-tea is always improved by adding some good stock; it should not be strained, as the sediment contains much nutrition. Beef-tea is more stimulating than nourishing; and if relied on as the only article of diet, would land the patient in starvation ; it is known to contain only 2 per cent. of solid material.

Next on the list stands the *broths*. These are the result of meat *boiled* in water, the meat being either strained off, or served in it. They are flavoured with vegetables or not, according as advised. The goodness of the meat is extracted by slow boiling, and if the meat is left in it, the substance is tender and lighter of digestion. Soups are the same as broth, with the addition of good bone stock, and the flavouring of vegetables. The various materials are strained away, and the liquid remains, combining the taste of the ingredients in judicious proportion. These latter are not so nourishing as beef-tea, and require a stronger stomach for their digestion ; but they are a valuable article of food, and deserve much more attention from the working classes than they get.

The *essences* of meat, as their name betokens, are made with less water and more time. The object aimed at is to extract all the properties of the meat by the prolonged action of heat in a closed vessel, and if satisfactorily done, the residue should consist only of the fibre and insoluble part of the meat.

The *extracts* of meat are deficient in albumen, gelatine and fat; in fact they can hardly be called food at all. They are of a highly stimulating nature, and are a good addition to ordinary beef-tea or soup.

Raw-meat juice is, as its name implies, juice of the meat extracted without the aid of heat. This is done by macerating the meat in a suitable quantity of cold water, and then finishing the process by pressure. The addition of a little muriatic acid brings out the juice quicker.

Beef is the juiciest of meat; next to it is mutton; veal and chicken have but little juice.

Malted Foods are farinaceous foods, either malted as part of their preparation, mixed with malt-meal, or eaten with malt extract or maltine. Malting is the term applied to the action of damp and heat upon grain, causing it first to germinate, and then stopping the germination at a certain point by the heat of a boiler. The result of this process develops a peculiar active nitrogenous principle called *diastase*, which has the power of converting starch into dextrine and sugar. *Barley* is the grain which is converted into true malt, hence the malt meal; and foods are called malted when they are mixed with this meal, or when the malt extract is eaten with them, or before them.

They are very useful foods for all delicate subjects, as the starch in the grain is changed into dextrine and sugar, a substance that is much easier of digestion than in the form of starch; they are also palatable, and taken by young children with relish.

Dr. Fothergill says: "In order to secure all the advantages which can possibly be derived from malt extracts, it is necessary to follow Nature's processes, not to traverse them. Consequently, malt extract should be taken either with farinaceous food, or immediately after such food. For the first it is admirably adapted, by its properties being sweet and toothsome, so that it can be added to farinaceous messes, with or without milk, previous to their being eaten. One caution is, however, necessary, and that

is, that it should not be added until the mess has so far cooled that it can be sipped. Diastase is killed by a temperature *above* 147° Fahrenheit, and this is the highest temperature at which anything can be sipped. It may either be mixed throughout the food, and be eaten with it, as the case may be, or it may be taken immediately after the food, so as to operate before the stomach becomes too highly acid.

"Beyond such use as an artificial digester of farina or starch, malt extracts have a lesser utility. They contain the phosphates of the grain and a certain portion of the starch converted into sugar or dextrine, consequently they are highly nutritive. They can thus be advantageously added to milk, either for infants or invalids."

Malt foods alone are insufficient for nutrition from the deficiency in fat and nitrogenous matter, and partly from lack of animal element—this deficiency may be supplied by the addition of cream or new milk.

It is of importance that these foods should be estimated at their just value, that more may not be expected of them than they are able to do. In their proper place, they are valuable additions to the invalid's dietary; but if put forward as summing up in themselves everything necessary for nutrition, it is giving them a character which they cannot sustain.

Peptonized Foods are foods artificially digested by the aid of the animal digestive fluids, so that they should enter the stomach partially digested. Strictly speaking, peptonized foods were those foods in which the nitrogenous elements were converted into peptones by the action of pepsine, i.e., gastric juice, and they were distinct from pancreatized foods wherein the fats were changed into emulsion by the action of the pancreatic juice.

Recent researches have discovered that pancreatic juice will act upon the nitrogenous elements as well as the fats and starches, so that foods treated with the Liquor Pancreaticus are *peptonised* and pancreatized, therefore the term "peptonized" covers the whole ground.

It is certain that in the case of a weak digestion, or of a stomach weakened by an acute illness or fever, the action is facilitated by a previous digestion—that which it was unable to do for itself, is done before the food enters the stomach.

The digestive action is increased by the action of heat, and for this reason it is that a definite temperature is insisted on in mixing the pancreatine with the food. Added to the milk with out preparation it is found to aid in the digestion of the milk, probably by passing the milk into the stomach already supplied with its digestive. This is a great addition to the means at our disposal for nourishing a delicate frame.

In planning the *menu* of an invalid the great object to be aimed at is variety, that is half the battle,—on what plea mutton is served up in the wards of workhouses and infirmaries, and in some hospitals on 365 days in the year passes comprehension, the patients, especially those with prolonged illness, must eventually turn from it with loathing. It has the character of being more digestible than beef and of containing more nutrition; but if it is refused by the patients, or eaten without an appetite, it had better be still running about as a sheep.

It is a good road to success to send up always a surprise dinner, some little delicacy that the patient is known to fancy, or even so ordinary a dish as a chop if carefully cooked and daintily served will tempt the appetite—to worry the invalid somewhere about nine or ten in the morning for the orders for the day is a great mistake, a great deal of contrariness will be called into action and the relish for the food lost. If an invalid has any particular likes and dislikes they will certainly volunteer them, for as a rule they think too much about their food.

Another mistake in dieting an invalid is the endeavour to tempt the appetite by some savoury but unwholesome dish; as a rule highly-spiced and seasoned dishes are quite out of place; the seasoning should be simple though tasty, and the food suitable for its work. Sausages, saveloys, and such like compounds of meat, are not food in the right

sense of the word, and take the place of more nourishing materials. Potted meats, if they are carefully done, are quite admissible, and are a toothsome relish. There is scope for much ingenuity in the dietary of the invalid, and all such efforts are highly prized by those who have to drag on a weary and monotonous existence.

The subject of food in acute illness has purposely been omitted, for it is beyond the province of this Handbook to enter the physician's territory ; but it may be laid down as a safe rule, that fluid food must be given in all fevers and in illnesses that set in with severity—it can never be amiss to give milk freely, until the patient is dieted, beef-tea, or light soup if there seems much exhaustion—all solids, tea, coffee and cocoa must be out of the question until the diagnosis is made. When the doctor takes charge of the case, he will lay down the rules for feeding, and it is needless to say that they must be strictly obeyed.

CHAPTER IV.

COOKERY FOR INFANTS AND INVALIDS.

IN the preparation of the food there is so much that is of general application that the two branches of the subject can best be dealt with in one chapter. In both is the same intelligence required, for both the same exactitude and attention to detail, for both the same scrupulous cleanliness and nicety. It is difficult in hospitals to have these points attended to, the materials are dealt with in bulk, the cook does not follow her cooking to its destination, and moreover there is much to be done and few to do it, so that when any marked attention is required, or alteration suggested in the usual mode of preparing a dish, the kitchen authorities are apt to resent the intermeddling. Whatever cooks may be in the political life, in their kitchens they are always eminently conservative. The qualifications for a good cook are, scrupulous cleanliness, exactitude, quickness of perception, an elementary knowledge of the substance which she handles, an inventive taste for her work, so that she may not just follow on a beaten track, but that the rather she may think out for herself how best to reach the end in view, quickness and promptitude with decision in her work.

The object of all cooking is to render food palatable by improving its taste and appearance, to make it digestible by commencing the process of disintegration by the agency of heat, to develop its nutrient qualities either by combination, or by placing its parts in new relations. The aim of cooking should be to retain as much as possible of the juices in the meat, at the same time that the meat is "well-done," not on the one hand done to rags and hard, or on the other half raw and unappetising. The mode

adopted should seek this end by the intelligent application of means to an end. For instance, old and tough meat will be rendered tender by stewing, when boiling or roasting would harden; boiling will develope and conserve the nutrition of chops and small parts of meat, whilst roasting or frying would shrivel them up, and so on.

Cooking must not be hurried; its arrangements have to be well thought over, and its various processes conducted with deliberation; a cook who is always behindhand will never be efficient.

The processes of cooking are roasting, baking, boiling, stewing, broiling, frying; of these roasting is the most appetising, boiling the more economical—in both cases, the meat must be first subjected to great heat for five or six minutes, so that the albumen on the surface may be hardened, which prevents the escape of the juices inside, the heat must then be lowered, and kept at *slow*, so that the interior may be subjected to its influences and the meat all rendered tender; if this process is continued too long the flesh becomes hardened and indigestible. The usual time required is fifteen minutes to a pound of meat. It is a mistake to put a fork in to test the tenderness of the meat, this makes holes, through which the juices escape. The meat cooked for invalids must be rendered quite tender, or it is unfit to be eaten, and its nourishment must be conserved as much as possible. If a slice of meat is the food, it should be taken from the middle of the joint and have plenty of gravy.

Stewing is an economical, appetising, mode of dressing meat; it must be done slowly in a closed vessel, so that all the aroma and juices, &c., may be saved. If vegetables are included they make a savoury nourishing dish. The vegetables must be boiled separately, as they require *boiling*, whilst the meat must be kept from boiling.

Broiling is a quick and ready mode of cooking thick fleshy parts of meat; if done over a quick clear fire, the albumen is hardened on the surface, retaining the juices, and the result is an appetising nourishing meal. The meat

must be turned frequently, *not with a fork*, and it should not be sprinkled with salt until taken from the fire.

Frying is a much more delicate, risky operation ; if done with over-heated fat and an insufficient quantity, the fibrine becomes hardened and tough—it requires enough melted fat *to cover* the meat, when it may be fried without being hardened. The meat is never so nourishing as that boiled.

The flesh of young animals is not so nourishing as that of maturer age, mutton is more digestible than any other meat, but beef contains more nutriment—veal, lamb and pork ought not to form part of an invalid's, or young child's food. The flesh of poultry is light and digestible, but it does not contain the same amount of nutriment as beef or mutton, but it is good food to start with when the stomach has been weakened by acute illness and therefore is not strong enough to digest richer food. The flesh of game is richer, more savoury, and has less fat than that of poultry, it is as a rule a welcome variety in the diet of an invalid. The hare is very savoury and though not the most digestible it can be eaten with advantage : as a soup it is palatable and nourishing. Salted meat is not so nourishing as fresh meat, the process of salting has extracted some of the albumen, and the flesh is harder, this makes it unfit for children and invalids. There is an exception to this rule in bacon and ham, which are rendered more wholesome by the process of curing—the fat is easy of digestion and the flesh is nourishing and digestible—the rich unwholesome qualities of the pork have been improved by the process of curing.

The fluid preparations of meat require care and exactitude in their preparation ; where possible they should be made over-night, when the fat has time to cool and can be taken off. If the fluid is wanted at once, the fat may be "*blotted*" off by a piece of kitchen paper. A greasy beef-tea or broth will set a patient against the food, and is certainly a sign of careless cooking.

In preparing pounded meats, care must be taken to have

the whole reduced to a fine mass, so that it can be passed through a sieve; the object of pounding is to break down the fibrine, thus passing it into the stomach more ready for digestion, also to take the place of mastication where the teeth are deficient.

Raw meat pounded should be quite free from fat, sinew, or gristle, and if properly done it is like a pulp. It may be eaten with milk or beef-tea, or sweetened with either white sugar or confection.

Fish has at all times been looked upon, and with reason, as a good form of aliment for the sick and for children, though the kind of fish selected and the mode of cooking must have careful thought. An exclusive fish diet is not to be recommended; it is not sufficient, and may induce an eruption of the skin. Among fish, the red and white fish is the most suitable as an article of food; it should be well-cooked and made tasty. Boiling is the most wholesome mode of cooking but it is the least palatable; if frying be resorted to, it is better to use oil than fat or butter; fish so treated is highly nutritious and very appetising. A good cook should have no difficulty in dressing various dishes of fish so as to combine variety with digestibility, and anything is better than the monotony of fried fish, boiled fish,—boiled fish, fried fish. Among the white fish, the cod is not suitable for a weak digestion, as it is hard and dense, if preferred it should be cut in small pieces and dressed as steaks, being made quite tender. The salmon, at the head of the edible fish tribe, may be eaten if cooked thoroughly.

All *shell-fish* must be put upon one side except *oysters*, these, when eaten raw, are nutritious and easy of digestion, it is well to take away the hard muscle at the conjunction of the shells. Oysters when cooked are not digestible. Great cleanliness is necessary in the preparation of food; meat when received from the butcher's should be washed, but not by the violent action as that carries away the juices—it must have contracted some foulness from the, shop or from the various means of transit, besides, it clears away the remaining particles of blood. Fish likewise

should be thoroughly examined and washed—a cook cannot be too fidgetty in these particulars.

All articles that are destined for consumption by either infants or invalids should be quite fresh—a healthy stomach may not suffer from eating tainted or sour food, but it may be most pernicious to the delicate. Great care must be taken in the storage and use of milk, the fluid readily decomposes, and any vessel not scrupulously clean, or any mixture of sour particles with sweet, will start the degenerative changes and spoil the whole quantity. The vessels must be *scalded* over night and kept in a covered place for use.

In using the milk for infant's food the food should be made fresh each time, and always in a clean vessel; it is a mistake to stand "baby's saucepans" on the hob to keep it warm between times, as the remnants left in it will certainly begin to decompose. This rule should be attended to through the night, though it may be irksome to get up in a cold night to make the baby's food—however, it is quite possible to keep a vessel with water hot all night which will much facilitate the process. The temperature of the food should be about that of the mother's milk, viz., about 95° to 98°, certainly no cooler. Attention to these details will be rewarded by the good health and content of the nursling—a nurse who rears a babe successfully by hand and starts it well on its career may well be proud of her work. All food prepared for the nursery should be thoroughly well cooked, and yet not over-done, as the substances become hardened by over-cooking. The farinaceous preparations should be mixed free from lumps, for lumps do not become heated equally and so are a source of irritation in the stomach; when eggs are used it is better to make the mixture an hour or more before it is cooked, as it becomes light by standing—when making a batter beat the eggs apart *very* lightly and pour them into the mixture, they will rise whilst standing.

As a rule all *pastry* is indigestible because of the action of the oven on the fat contained in it, and though a very

popular article of food, especially among the young, it ought not to find a place in their dietary, nor should it be eaten by those who have weak stomachs.

Boiled puddings in which there is fat are also indigestible.

Baked flour is the best form in which to use it for the delicate, it may be either baked by simply putting it in the oven, or by tying it up in a basin with boiling water around it—the flour collects in a hard solid mass, and it may be scraped or grated for use. The effect of heat is to break the starch granules and prepare them for the action of the digestive fluids. Milk thickened with this flour and sweetened is a nourishing wholesome dish.

Some stomachs find that milk is too heavy for them, the fault may be either that it is too rich or that the re-action of the stomach is too acid—soda-water or lime-water will be useful for diluting the milk and correcting the acidity of the stomach, or the milk may be made into whey. Whey is the liquid left after the curd has been separated by the action of rennet; the whey may then be used as a drink, or as a gruel with some of the prepared flours.

Baked milk is more palatable than boiled milk, and those who advocate its use assert that it is more digestible.

Jellies and gelatinous preparations are great favourites with some, as representing a vast amount of nourishment in a small bulk. The squire's wife makes jellies for her sick dependants, and places them on the same level as beef-tea. This is a mistake, a good jelly is not a sign of nutriment, for all that is needed to make a jelly is *gelatine*, no matter whether you have it in the fresh state by stewing bones and cartilage, or whether you buy it as the gelatine of commerce. Jelly is useful as a vehicle, for it lends itself readily in combination with various nutritive substances; it is agreeable to the palate and is easily digested. Beef tea made into jelly by the use of isinglass or gelatine, will combine with port wine, and is both stimulating and nutritious.

Jelly for the sick room should be made from fresh materials, calves' feet, and flavoured with sherry, only enough sugar to be used to give a slight taste of sweetness.

Carageen moss, which by some is recommended for consumptive patients, the scrofulous, and for some forms of asthmatic cough, may be made into a jelly and eaten with milk, or the milk may be combined in the jelly. If the jelly is made with water, it may be flavoured with lemon peel, white wine and sugar.

Vegetables, especially potatoes, must be thoroughly boiled, and all woody, fibrous parts and stalks be removed. It is a good plan to dry mash the potatoes for an invalid, and pass them through a sieve; they may be lightly browned in the oven, which gives them a tempting look. Potatoes must not be cooked in any other way for invalids. Much care is necessary in cooking a potato, and for this reason how few people do it well. Potatoes are better steamed than boiled; when properly done they should look like a ball of flour, and be soft all through. If waxy or sodden, they are not fit eating for weak people; this fault may be from careless cooking, i.e., keeping them too long in the water after they are cooked, or because the potato is not a good kind. Steaming is more economical than boiling, and it is easier to carry through properly. A potato as a rule takes half an hour to boil, and except in the case of new potatoes, they should be placed in boiling water.

The best potatoes should be selected, with few eyes and with no sign of germination, which makes the potato waxy. They have a finer taste, and waste less if cooked with their skins on.

Green vegetables require care in washing and in stripping; the parts used must be fresh and tender, all animals and insects removed—a delicate appetite is very sensitive to the corpse of a young slug or snail; before being served they must be well drained, and be sent up quite hot. Melted butter is not admissible for an invalid, but a substitute may be found—oil may be used instead of butter.

Eggs will adapt themselves to any style of cookery, they are most useful in the invalid's dietary; to diet an invalid who cannot eat eggs presents a most difficult problem.

In whatever way they are cooked, they should always be done lightly, otherwise the white hardens and is indigestible; an egg poached is the best form of cooking, it should be served with the white just set. Fried eggs though tasty, are not wholesome, likewise hard boiled eggs are indigestible. There are many ways of cooking eggs that will suggest themselves, either plain or in combination with some other material. Beaten up raw in milk, with wine, or in beef-tea they are nourishing and stimulating; with beer and water and some flavouring spice they make egg-flip. When they are taken raw, they should be beaten very thoroughly, by this means air is entangled in the fluid, and the glairy consistency is done away with. In the form of an omelette they are agreeable and nourishing, only how few can make an omelette well; it requires promptitude and decision, for if you let the happy moment pass by whilst thinking about it, it turns out leathery.

This chapter on cooking can hardly conclude without drawing attention to the Jewish mode of cooking and style of living. Its admirers claim for it great wholesomeness and adaptability to a weak digestion, and it is certainly worthy of note that the Christian children compare unfavourably with the Jewish in healthiness, longevity and power to resist disease. There are many factors in operation to account for this; but undoubtedly, the diet must have something to say to it. Readers of the Bible will be acquainted with the list of animals allowed for food, and the mode of killing prescribed. These precepts are still observed, especially among the poor Jews.

Their meat is most minutely inspected, to ensure its cleanliness and healthiness, by an independent authority; all that is diseased, tainted or bruised is rejected and destroyed. Very strict cleanliness is insisted upon in their slaughter-houses, and the slaughterer has to learn his work systematically, being taught a slight outline of anatomy *before* he is allowed to try his hand upon the poor beasts. The weapons used must be of the keenest, as any bruising

or lacerating in the wound made, renders the food unfit for consumption.

In the combination of their food, they never mix milk or its products with meat; this by them is regarded as a breach of the precept "Thou shalt not seethe a kid in its mother's milk;" the principle is that food killed by violence should not be mixed with that which is rendered up peacably, the mixture is an abomination. The idea may seem fanciful, but at least it has the merit of antiquity, and my object in drawing attention to the subject is, that it may receive some consideration as a system of dietary.

The rule laid down may at first sight appear restrictive; but the study of a Jewish cookery book will show that their dishes will equal ours in variety and taste, and that a very good meal may be planned and carried out by an intelligent housewife.

We might certainly take a lesson from their scrupulous cleanliness, which accompanies the meat through all its stages until placed on the table, and any system that would strike at the root of our monstrous dinners, so unwieldy, so unwholesome and so extravagant, is to be welcomed. An article in the "National" has drawn attention to this modern failing—it is to be hoped that the word in season may be heard.

Some who suffer from imperfect digestion having tried the Jewish system, affirm that it suits them much better, and the advocates of it assert that the secret of its healthiness lies in the absence of mixed foods, that for this reason it makes better blood, and that the whole vital system is purer.

Considering the great diversity of idiosyncrasy, and the varied circumstances that surround the human family, it is not to be expected that every one should feed alike; the great secret of maintaining the health, or improving it, is to bring common sense to bear upon the question. Our food should not occupy a great place in our thoughts, nor should the amount taken exceed that which we require for repair and nourishment; we may have likes and dislikes,

so long as they are in subordination; but fancies are inadmissible, being, as their name implies, baseless and wayward. Even in the act of eating and drinking we may find scope for self-discipline and self-development, if we make it a means of controlling our appetites. And so we bid farewell to the Infants and Invalids, both of importance in the history of a nation, the one representing its future, the other, some of its unused material that may have much to do in moulding that future if only some of the obstacles are removed; with the hope that some of the hints in these pages may give a fresh impetus to the one and soften or ameliorate the life of the other.

FOODS CHARACTERISED BY A PREPONDERANCE OF

Nitrogenous, Matter.	Starch.	Sugar and Fat.		Mineral Salts.
Meat.	Wheat.	Figs.	Sugars.	Cabbages.
Poultry.	Flour.	Bananas.		Spinach.
Game.	Bread.	Honey.		Watercresses.
Wildfowl.	Biscuits.	Treacle.		Radish.
Fish.	Oatmeal.	Manna.		Tomato.
Milk.	Barley.	Grapes.		All kinds of Fruit.
Eggs.	Rye.	Beer.		
Cheese.	Indian-Corn.	Butter.	Fats.	
Cocoa.	Rice.	Cream.		
Green Vegetables.	Buck-Wheat.	Cocoa.		
Tripe.	Beans.	Chocolate.		
Oysters.	Peas.	Eels.		
	Lentils.			
	Chestnuts.			
	Potatoes.			
	Carrot.			
	Parsnip.			
	Sago.			
	Tapioca.			
	Macaroni.			
	Arrowroot.			

A LIST OF RECIPES REFERRED TO IN THE FOREGOING PAGES.

Arrowroot Jelly.

Put into a nice silver or block-tin saucepan, a pint of water, a glass of sherry or a dessert-spoonful of brandy, a little grated lemon-peel, and some fine sugar; boil it up once, then mix it by degrees into a good dessert-spoonful of arrowroot, previously rubbed smooth with two teaspoonsful of cold water—return the whole into the saucepan and boil it for three minutes, stirring it all the time.

Barley Water.

This medicinal drink is made from the pearl or Scotch barley, and may be either taken in its simple form, when cold, or flavoured with some of the substances given below. As there is some art required in making barley water properly, the following mode may be adopted with advantage. Take of,

Clean pearl barley . . .	2 oz.
Cold water	4½ pts.

Pour half a pint of the water on the barley in a saucepan, and simmer slowly for ten minutes; pour off all the liquor remaining, and add the four pints of water to the softened barley, and boil slowly till the quantity is reduced to one half; strain into a large jug, in which one or two slices of a lemon have been placed, with a few lumps of sugar. When cold, and properly stirred, a cupful may be taken repeatedly. The juice of a few oranges, with an ounce or two of bruised sugar-candy, or a quarter of a pound of tamarinds, may be substituted for the lemon, and when sufficiently mixed by stirring, the whole is to be again

strained to keep back the seeds, twigs, and stones, and according to the ailment for which it is used, a wineglassful of the drink given every one or four hours. In inflammatory diseases, or cases of bleeding from the lungs or stomach, a better form of barley water is made by adding to the two pints of boiled liquid, 1 oz. of simple syrup and $1\frac{1}{2}$ drms. of the red elixir of vitriol; while in cases of cough, or affections of the chest, a cool, relaxing draught, acting on the vessels of the throat and chest, is produced by adding 1 drm. of powdered nitre to each pint of barley water, and a tablespoonful taken every hour or two. Barley water, made as above, in which 2 ounces of gum-arabic have been dissolved, and a drm. of nitre added, makes an admirable drink in all affections of the bladder, and in cases of strangury.

BEEF-TEA.

Beef-tea, which is so valuable in cases of illness, is usually made by boiling the meat in water: this is a bad plan, as the fibres are hardened, and the soluble portions less readily extracted. It should be made by pouring a pint of cold water on half-a-pound of finely-cut or chopped lean beef, and then placing it, in a covered earthenware vessel, by the fire for an hour or two. By this means the whole of the soluble, nutritious portions are extracted, and the insoluble fibre alone remains. A small quantity of salt and two or three cloves greatly improve the flavour. Carrots and turnips stewed in the beef-tea and strained out are sometimes used in hæmorrhagic typhoid fever with great advantage.

BEEF-TEA (Savoury).

Take three pounds of lean beef chopped up finely, three leeks, one onion with six cloves stuck into it, one small carrot, a little celery seed, a small bunch of herbs, consisting of thyme, marjoram, and parsley; one teaspoonful of salt, half a teacupful of mushroom ketchup, and three pints of water. Prepare according to the directions already furnished.

Liebig's Beef-tea.

Take half a pound of raw lean beef (chicken or any other meat may be similarly used), and mince it finely. Pour on to it, in a glass or any kind of earthenware vessel, three-quarters of a pint of water, to which has been added four drops of muriatic acid, and about half a saltspoonful of salt. Stir well together, and allow it to stand for an hour. Strain through a hair sieve, and rinse the residue with a quarter of a pint of water. The liquid thus obtained contains the juice of the meat with the albumen in an uncoagulated state, and syntonine, or muscle fibrine, which has been dissolved by the agency of the acid. It is to be taken cold, or if warmed, must not be heated beyond 120° Fahrenheit. It will be observed that no cooking is here employed, and although much richer in nutritive material, and more invigorating that ordinary beef-tea, the raw meat—colour, smell, and taste that it possesses—sometimes cause it to be objected to.

Beef-tea (Another way).

"A nutritious broth," says Letheby, "containing the albumen of the meat, as well as the soluble extract, is obtained by infusing a third of a pound of minced meat in fourteen ounces of cold soft water, to which four or five drops of muriatic acid and a little salt (from ten to eighteen grains) have been added. After digesting for an hour or so, it should be strained through a sieve, and the residue washed with five ounces of water and pressed. The mixed liquids thus obtained will furnish about a pint of cold extract of meat, containing the whole of the soluble constituents of the meat (albumen, creatine, etc.), and it may be drunk cold, or slightly warmed, the temperature not being raised above 100° Fahrenheit, for fear of coagulating the albumen.

Bread Jelly.

A thick slice of bread made of seconds flour, as containing more of the nitrogenous element than the best

white flour, and three days old, so as to be well dried and sweet, is placed in a basin of cold water, and allowed to soak for eight hours. All the water is then thoroughly squeezed out of it. The object of the first soaking and removal of the original water is to clear away the lactic acid formed in fermentation, and all other irritant matters. The pulp is then placed in fresh water, and gently boiled for half an hour. The object of the boiling is to thoroughly soften and break up the starch corpuscles, which are insoluble in the digestive fluids of young children. This water is strained away, and the remaining pulp rubbed through a fine hair sieve. It is then allowed to grow cold, when it should form a fine, smooth, jelly-like mass. Enough of this is then mixed with warm water to make food of the consistence of thin cream, so as to pass readily through the bottle.

Boiled milk is added—at first only one or two teaspoonfuls to the half bottle—and a little white sugar. The milk is slightly increased every few days, as the child is found able to digest it, and then it is gradually advanced at six or eight months old to pure milk, thickened with the jelly.

The bread pulp should be freshly prepared night and morning, for it will not keep long.

CHICKEN PANADA.

Take a large fowl, strip it of both skin and fat. Put it to boil in as much water or stock as will cover it. When done, take off all the meat, and pound it in a mortar till quite fine. Then mix it in the water it was boiled in, skim off all the fat, and strain it three times through a sieve, then put it into small cups and let it stand in warm water to dissolve and warm for eating.

This may be made thin with veal broth.

Half a cup to be taken twice a day.

Chicken Jelly.

Have a chicken prepared by taking off all the skin and fat, cutting it into pieces, and when thoroughly well mashed placed in a stone jar with a small piece of mace, tied up in muslin, and a little salt. Put to it one teacupful of cold water, then tie down the opening of the jar with thick paper. Set the jar in a saucepan of *warm* not boiling water, put it on the hot hearth and let simmer for some hours—1 lb. and half of veal or beef can be made in the same manner.

Crême d' Orge.

1 lb. of fresh veal, 1 lb. of fresh beef, 2 ozs. of pearl barley, stewed for six hours and then squeezed through a tammy—seasoned to taste. The proportion of water is three pints reduced to one pint.

Eggs Stirred with Butter.

Break as many eggs as you require in a small basin, beat them well with salt and pepper to taste, have in a small saucepan an ounce of butter, warm it well, turn in the eggs, keep stirring them with a fork, dish up on a hot dish, have hot plates ready.

Eggs with Butter Whole.

Have a small white dish or plate that will stand the fire, put it on the hob quite close to the fire, put a good piece of butter (½ oz. will be enough for 6 eggs), sprinkle a little salt and pepper, crack the eggs in a cup, slip each one separately on the dish that is ready to cook them, they will set nicely, put over them a little salt and pepper so that they will be seasoned right through, send them up to table on the same dish another dish under.

Flour and Milk.

Fill a small basin with flour and tie it over with a cloth, or if preferred, simply tie the flour up in a cloth. Immerse

it in a saucepan of water and boil slowly for ten or twelve hours.

The flour becomes agglomerated into a hard mass, and is only wetted on the surface. After drying, add one grated tablespoonful to a pint of milk and boil. A nourishing and useful article of food for irritable states of the stomach and bowels, and particularly suitable in dysentery and diarrhœa.

Plain biscuit powder may be substituted, if thought proper, for the cooked flour.

Hominy.

Wash it in two or three waters, pour boiling water on it, and let it stand all night. Take it out, and put it in a saucepan, one quart of hominy to two of water, and boil four or five hours till quite soft. Drain it, put it into a deep dish, and stir in some butter. If any is left cold, cut it in slices and fry it.

Iceland Moss.

Boil ½ oz of Iceland Moss in 5 noggins of water, on a slow fire, to 1 pint. Add two dessert spoonfuls of soft sugar, strain it. Two table spoonfuls may be taken three or four times in the day. If you like you may add a spoonful of milk to each dose. Keep the bottle in a cool place. It answers to put the bottle down in cold water.

Isinglass Jelly.

Take of Isinglass 1 oz., water one quart, cloves ¼ of an oz. Boil to a pint and then strain the liquor through a flannel bag upon 4 ozs. of double refined sugar, and one gill of mountain wine. When they are well mixed pour the jelly into glasses.

To make Koumiss, or Artificial Mare's Milk.

To eight cups of new milk add one cup of buttermilk. *Let it stand* at a little distance from the fire until it grows

thick ; then beat it smartly with a whisk, for about ten or fifteen minutes, adding two lumps of sugar to prevent it going into butter, and then bottle and cork it. Let it be well shaken when you give it to the patient, and the hand held high in pouring it out, that it may froth. If this is too rich for the stomach, a cup of water may be added on making the next quantity. A cup of this to be kept for the next brewing, as it answers better than buttermilk.

It will be ready for use a few hours after it is bottled, and a sufficient quantity may be made to last at least two days, provided it be not kept in too warm a place, and care must be taken that the bottle does not burst.

To make Lemonade.

For a large quantity, take the rinds of four very fresh lemons, cut up as fine as possible, put it in two quarts of water, cut the lemons in halves, squeeze them through a sieve in the water, boil 1 lb. of loaf sugar with a pint of water to a syrup. When cold, turn the syrup into the water, stir it all well together, if not acid enough put more lemon or more sugar if required, let it stand for an hour before using. This drink is very nice iced in the summer.

Meat Essence.

Take 1 lb. of mutton (from the middle of leg) 1 lb. of beef and 1 lb. of veal—without skin, bone or fat. Put in earthenware jar, tie tightly down. Put the jar in a saucepan of water, boil 8 hours, strain ; when cold remove all the fat, it is then fit for use.

Milk Soup.

Four large potatoes, two leeks, two ounces of butter, three tablespoonfuls of crushed tapioca, one pint of milk. Put the potatoes and leeks, cut in four, in a saucepan, with two quarts of boiling water and two ounces of butter, a teaspoonful of salt, and pepper to taste. Boil an hour, rub through

a colander, and return it to the saucepan, add the milk, sprinkle in the tapioca, and let it boil fifteen minutes.

Milk and Suet.

Boil one ounce of finely-chopped suet with a quarter of a pint of water for ten minutes, and press through linen or flannel. Then add one drachm of bruised cinnamon, one ounce of sugar, and three quarters of a pint of milk.

Boil again for ten minutes and strain. A wineglassful to a quarter of a pint forms the quantity to be taken at a time. It constitutes a higly nutritive and fattening article, but if given in excess is apt to derange the alimentary canal, and occasion diarrhœa.

Mutton Broth.

Take of a loin of mutton, one pound, water three pints —put them in a saucepan, and set it upon a clear fire, throw in a little salt, and as the scum rises take it carefully off with a spoon—then add a little onion if there is no objection to it, and 2 blades of mace. Boil till the meat is very tender, then take it out, pour the broth into a basin, and when cold skim the fat part which is congealed on the surface entirely off; after which a part of the broth may be warmed and given to the patient when needful. A little rice may be added here occasionally.

Mutton Chops with Tomatoes.

Take some nice mutton chops with the fat trimmed off, put them in a stewpan with salt, pepper, and onion chopped, slice 3 or 4 large tomatoes. Let all cook together with about a cupful of water. When the chops are tender take them out, let them drain well from the gravy, then turn the tomatoes and liquor into a sieve, pulp it well, it will be quite thick, put the piece of a lemon with it. Turn it all over the chops. Let it boil before you dish it up, sprinkle over a little chopped parsley, if liked a little cayenne is always an improvement to the tomatoes.

Porridge.

The best method of making porridge is to strew oatmeal with one hand into a vessel of boiling water (to which salt has been previously added), so gradually that it does not become lumpy, stirring the mixture all the time with the other hand. After about four ounces of coarse oatmeal have been stirred into a quart of boiling water, the whole should be allowed to stand by the side of the fire, so as to simmer gently and thicken for twenty or thirty minutes. Porridge is usually eaten with milk. It is excellent for children.

Semolina.

Semolina is coarsely ground wheat, and is very nutritious. Boil one tablespoon in half a pint of milk ten minutes, stirring all the time, sweeten with one dessert-spoonful of powdered white sugar ; it can be eaten hot, or put in a shape to turn out cold. To make it into a pudding, add one egg lightly beaten and bake fifteen minutes.

Tomato Soup.

Have 6 or 7 large red tomatoes ; cut them in halves, put them in a saucepan at the side of the fire with no water, let them simmer till quite tender, rub them through a sieve till only their skins remain. Have a quart of stock ready at the side ; stir them well in till it is quite smooth ; have ready in your tureen the juice of a lemon and a little cayenne.

Many persons like toasted bread with this soup.

An Easy Way to Cook Tripe.

Have it well washed and cleaned, boil it in a saucepan in thin flour and water to keep its colour, salt and pepper. When done strain it out of the water, slice an onion in a stew pan with a little fat, salt, pepper, grated nutmeg, half pint of the water in which it was boiled ; let it cook for

half an hour; have in a basin some chopped parsley, a few capers, a teaspoonful of flour, a little dried saffron, 1 table-spoonful of vinegar, mix it all well together; dish it up; serve with mashed potatoes.

White Wine Whey.

To half a pint of milk whilst boiling in a saucepan, add one wine glassful of sherry, and afterwards strain; sweeten with pounded sugar, according to taste. A useful drink in colds and mild febrile disorders.

ALCOHOLIC DRINKS.

BY

J. L. W. THUDICHUM, M.D., F.R.C.P. (LOND.), ETC.

CONTENTS.

WINE.

BEER.

DISTILLED SPIRITS.

LIQUEURS.

ALCOHOLIC DRINKS.

WINE.

THE vine grows naturally in the temperate parts of Western Asia, the south of Europe, Algeria and Morocco. In Armenia, and to the south of the Caucasus and the Caspian Sea, it exhibits its quality as a creeper, and ascends high trees, bearing fruit without being either cut or otherwise tended. It grows vigorously in ancient Bactriana, in Affghanistan and Badackshañ, and in Cashmir. I have studied it in the Algaida, a forest of about 9000 aranzadas in extent, situated on the south bank of the Guadalquivir, to the east of San Lucar de Barrameda. This forest consists mainly of sea-pines (*Pinus maritima*), but contains also groups of the silvery elm. Almost its entire border, and many small and large open spaces in its interior, are lined with the wild vines first described by Clemente. I found vines covering the whole of large fir-trees, silver elms, oleander bushes, fig-trees, and, together with sarsaparilla in blossom and brambles, creeping up and covering shrubs of lentiscus. These garañonas, as the Spaniards term the wild vines, are really indigenous plants, and not stray children of the vineyard; for all the flowers which I observed had the *stamina recurvata*, which are the characteristic feature of the female type of the *diœcic* wild vine, and no erect stamina (cfs. Thudichum and Dupré's 'Treatise on Wine,' p. 6, Fig. 3). I observed myself, in 1871, the place described by Clemente, where "the vines form impenetrable thickets, magnificent banqueting halls, most graceful pavilions, grottoes, covered walks, winding foot-

paths, labyrinths, walls, arches, pillars, and a thousand original and indescribable caprices." The wild grapes here are black, acidulous, but good to eat. The growth of the plant is so vigorous that a one-year's shoot, which I pulled from a tree, measured fifty feet in length.

That the vine lived in Europe in the tertiary period is proved by the evidence of fossils. That it was present in pre-historic times is shown by the occurrence of preserved parts of the plant in various situations. Thus vine seeds have been found in the remains of the lake dwellings of Castione, near Parma, under conditions which show that they belong to the Bronze Age, at least 9000 years before our time; other lake dwellings, such as those at Varese, in the province of Como, and at Wangen in Switzerland, exhibit similar proofs. Near Montpellier, vine leaves were found in tufas, which, like those of Meyrargue in the Provence, are pre-historic, but post-tertiary.

A. de Candolle is of opinion that the idea of producing grape-juice and allowing it to ferment might have originated with different nations, particularly in Western Asia, where the vine abounded, and grew well. It is unquestionable that the Semites, as well as the Aryans, knew wine long before historic periods, and were in a position to introduce it into all the countries to which they migrated, including Egypt, India, and Europe. They could do this the easier as they found the vine wild in several of the countries in which they arrived. As regards Egypt, we have documentary evidence that the cultivation of the vine and the making of wine were practised nearly six thousand years ago, namely under Phtah-Hotep, who lived at Memphis four thousand years before our era. The progress of the cultivation of the vine by Phœnicians, Greeks, and Romans, is well known. A. de Candolle says that towards the east of Asia it seems to have advanced so slowly that the Chinese do not seem to have cultivated the vine before A.D. 122, although several varieties of wild vines are known to occur in their northern provinces. This is, however, at variance with the statement of Welles Williams, according

to whom the first cultivation of the vine in China is ascribed to Foh-hi, a ruler estimated to have lived about three thousand years before the Christian era. It is further recorded that about 1120 B.C. wine was considered in the celestial empire to be dangerous to the state.

Each particular district producing a well-characterised wine does so by means of particular well-characterised varieties of vines. These vines must be either indigenous to these districts, or produced in them by natural or artificial selection from indigenous varieties. As we shall see in the consideration of particular viticultural districts, every uniform climatic region has its peculiarly-adapted varieties of cultivated vines, which cannot be so successfully cultivated in other regions, or sometimes cannot be cultivated at all anywhere else.

It is not necessary for our present purpose to investigate the particular steps in the progress of the human intelligence, by which wine, such as we know it now, was discovered. The shepherds of the Algaida gather the wild grapes in earthenware pots, and bury them in the ground under leaves and brushwood, and later on drink the fermented juice at their leisure. From such an original proceeding to the confection of Burgundy or of Champagne there are many stages, to describe which would require a separate treatise. We shall, however, in the following pages obtain sufficient information regarding the main features in the production of the principal varieties of wine to enable the reader to meditate on the subject of the origin of vinification.

Wine is the fermented, purified, and ripened juice of the grape; as such it contains alcohol, acids, salts, extractives, and those principles which give to it its particular colour on the one hand, and its particular flavour, smell, or bouquet on the other. While some of the ingredients can be accurately described and isolated, others are accessible to a definition by the sense of smell only. The conventional value of wine is determined less by its principal ingredients than by the prominence of the specific character termed

bouquet, and the absence of certain faults. Dietetically, most wines are of equal value, provided they are the products of a favourable season, are pure, and free from the faults produced by parasitic fungi.

The principal alcohol in wine is alcohol strictly so called, or spirit of wine, the chemical composition of which is expressed by the formula C_2H_6O. In rare cases there is some butylic alcohol, $C_4H_{10}O$, and in others some amylic alcohol, $C_5H_{12}O$, so-called fusel oil, present. The latter alcohol we shall have to consider more particularly in connection with alcohols produced by the fermentation of grain or malt, and distillation of the resulting liquid. The quantity of alcohol present in wine can be estimated by distillation, and ascertaining the amount of spirit in the distillate by the determination of its specific gravity, or by ascertaining the specific gravity of the wine, then driving away all spirit from it, and, having again brought it to its original bulk by the addition of water, ascertaining its specific gravity without the spirit. Other methods are less accurate. The quantity of alcohol present in natural wines from the grape varies between 6 and 12 per cent. Unsound wines may contain some aldehyde, C_2H_4O, produced from alcohol by the loss of hydrogen.

The acids present in wine are those naturally present in the grape, namely tartaric, malic, and tannic ; and those produced during fermentation, namely acetic, formic, succinic, and carbonic. In addition to these there are nearly always traces of the more complicated fatty acids, such as propionic, butyric, and œnanthic acid present. Tartaric acid, $C_4H_6O_6$, occurs in must as acid potassium salt, or so-called tartar, and is in part precipitated during fermentation, as it is less soluble in spirit than in water. During the ripening of wine, tartaric acid forms with alcohol tartaric ether. The tartaric acid most commonly found in wine turns the plane of polarised light to the right, and is therefore called dextro-tartaric acid. Some wines, however, *e.g.* Italian, contain also tartaric acid, which polarises to the left, levo-tartaric acid, always, how-

ever, combined with the dextro-tartaric acid, forming what is known in science as racemic acid. All three acids have one and the same chemical composition expressed by the formula $C_4H_6O_6$. Sherries contain no tartaric acid, as it is removed from the must of Jerez grapes by gypsum or plaster of Paris.

Malic acid, $C_4H_6O_5$, is not only present in grape-must, but in the juices of many varieties of fruit, which we shall have to consider—apples, cherries, plums, currants, and the red berries of the mountain ash.

Tannic acid is present in most varieties of wine, and is derived from the husks and kernels mainly; more rarely contained in the juice of the grape. Red wines contain more of it than white wines, because they are always fermented with the husks and seeds.

Succinic acid, $C_4H_6O_4$, in wine is one of the results of the fermentation of grape-sugar, which, in that process yields about a half per cent. of its weight of that acid. When the formulæ of succinic, malic, and tartaric acid are compared, it will be perceived that they all contain the same number of atoms of carbon and hydrogen, but not of oxygen, of which latter element succinic acid contains four, malic acid five, tartaric acid six atoms.

Acetic acid, $C_2H_4O_2$, occurs in wine and other fermented liquids, principally as the result of the oxydation under the influence of the air, of some alcohol. When the entire amount of alcohol in a fermented liquid is transformed into acetic acid, vinegar results. Vinegar from wine preserves some of the flavour of wine, and those accustomed to its use are therefore not inclined to exchange it for the more common vinegar made from fermented malt, or from acetic acid obtained by the fiery decomposition of wood. In good natural wine the amount of acetic acid does not exceed 1·78 per thousand, but is ordinarily only about a half per mille; in spoiled wine its amount may rise to 3·63 per thousand.

The œnanthic acid, to the ethylic ether of which most wines are supposed to be indebted for their characteristic

smell, has the formula $C_{14}H_{26}O_3$, and does, therefore, probably not belong to the same series of acids as acetic, propionic, and butyric acid.

In good, sound wines the total amount of free acid varies between 0·3 and 0·7 per cent; wines with more than the latter amount of free acid taste excessively sour, and are not easily digested.

The ethers in wine are aceto-ethylic, which contributes much to the general flavour of the wine; aceto-propylic, butylic, amylic, caproylic; further butyro-ethylic, caprylo-ethylic, capro-ethylic, and pelargo-ethylic; and the tartaric ethers. The characteristic smell of the œnanthic ether distinguishes all kinds of wine from every other fermented liquid. The flavour or bouquet, however, by which wines from different vines and vineyards are distinguishable from each other, is produced by substances which are already present in the grapes, and the effect of which is only heightened by fermentation. The volatile ethers in wine mostly surmount the fixed ethers in quantity. The alcohol obtained by the decomposition of all the ethers is rarely more than 0·06 per cent. of the wine.

Wines may contain more or less of sugar of one kind or another. Must contains a mixture of sugars, of which one polarises to the right, and is therefore termed dextrose, while the other polarises to the left, and is in consequence termed levulose. If wine contains cane-sugar, it has been added, *e.g.* to Champagne. Even added cane-sugar is under the influence of the natural acidity of the wine, gradually transformed into the mixture of dextrose and levulose; this mixture also goes by the name of invert sugar. Some wines, *e.g.* Sauternes and old sweet Rhine wines, contain also a peculiar sugar, occurring in flesh and brain, namely, inosite. All sugars in must and wine have the chemical composition expressed by the formula $C_6H_{12}O_6$, but differ in properties. They are, therefore, not identical, but, as it is termed, isomeric with each other.

Another sweet-tasting substance occurring in wine and *all* other fermented liquids is glycerine, $C_3H_8O_3$, originally

known as one of the constituents of animal and vegetable fats. During fermentation it is formed from sugar; 100 parts of cane-sugar, or 105·26 parts of grape-sugar, yield on an average 3·69 parts of glycerine, or one-fourteenth part of the alcohol produced by the same fermentation.

The colouring matters of wines are either natural constituents of the grape, or produced in must and wine during and after fermentation. Of the latter kind are most yellow and amber colours of natural so-called white wine. They are not rarely the result of the oxydation of astringent or tannic acids. But the red colouring matters are mostly contained in the husks, and dissolved only by the concurrence of the alcohol formed during fermentation and the acid naturally contained in it. The grapes from which some of the best red wines, *e.g.*, Burgundy or Médoc wines are made, yield an almost perfectly colourless juice if pressed before fermentation. But some rarer vines, and those yielding inferior wine, have, like the black currant, a coloured juice. Some of the red colouring matters contain iron as an essential chemical ingredient, and are therefore supposed to make the wines in which they are contained particularly wholesome.

Wine contains traces of ammonia, present in all vegetable juices; also albuminous matters, which are supposed to make the wine liable to undergo decomposition more readily. Wine also contains some substances which remain when it is evaporated to dryness, and are termed extractives. They have an agreeable smell and taste, and contribute to the smell and taste of wine in the same manner as the extractives of meat contribute to the smell and taste of meat and broth. Wine further contains a certain amount of inorganic or mineral ingredients, potash, soda, lime, magnesia, and phosphoric, sulphuric and hydrochloric acid in combination with the former. Sherries contain a large excess of sulphate of potassium, due to the treatment of the must with plaster of Paris, of which the results will be described under the paragraph relating to Jerez.

Wines of France.—The wines of France may conveniently be considered in five groups, those of Burgundy being the oldest known. Next to them, and from the same grapes, are produced the wines of the Champagne. In the south-west of France, in the valley of the Garonne and Gironde, are grown the wines commonly called of Bordeaux ; and in the south, in the provinces on the Mediterranean, the ancient Languedoc, are grown the wines termed in French "Vins du Midi." French wines are never treated with brandy to the same extent as the Spanish and Portuguese wines, and the highest qualities are never treated with any brandy at all. Plastering is only practised in the southern districts, and is applied more particularly to red wines. Sweet, or so-called liquorous wines, are produced in the southern departments, in the Sauternes district, and in the Champagne, but they differ in kind among each other, and the only wine that has any resemblance to the heavy Peninsular wine is the red wine of Roussillon. The art of producing wines of natural composition and strength is more developed in France than in the Peninsula. It is owing to this that France produces not only wines of eminent *finesse*, such as the Médocs and Burgundies, and that peculiar wine effervescent Champagne, but large quantities of wholesome low-priced natural wines and useful beverages, which, like the effervescent Saumur, do duty for Champagne.

Wines of the Bourgogne.—Burgundy is the oldest viticultural country in central Europe, and thence migrated the art of making wine to other parts of France and to Germany, Bohemia, and Moravia. In the Middle Ages Burgundy was the regular wine on the tables of the great and mighty of the world, but the place which it formerly occupied in society is now taken by Champagne. That part of Burgundy which produces the best wines is named the Côte d'Or, or "golden hill-side." It consists of a series of hills about thirty miles in length, which stretch from Chalon on the Saône to Dijon, in the direction of N.N.E. to S.S.W., their cultivated inclination and exposure being

consequently towards the east. They have a height of from 200 to 300 feet, and consist of a loose limestone mixed with a little clay. Burgundy has a mixture of vines in its vineyards, termed Passe-tous-grains. The black grape peculiar to the Bourgogne, the pineau or noirien, is dominating along the Côte, but in the ordinary situations, and in small vineyards, white and red grapes are found among the black. There is another vine, with larger berries, namely the Gamay, which dominates in the Mâconnais and Beaujolais, bears more abundantly, but gives a wine of inferior quality. Of white grapes the most frequently cultivated is the Chardenay, which prevails in the northern part of Burgundy, yielding among others the wine of Chablis. The vines are small, rise about a foot from the ground, and carry annually from three to four canes. The vintage takes place in September or October, the earlier vintages, being those of good years, generally yielding a better wine. The grapes are crushed and thrown into high vats to ferment. During fermentation, the husks and stalks rise to the top, and form the "chapeau." When the fermentation is completed, this top is distributed in the wine by mechanical means, to extract all the colour from the husks. Lastly, the wine is withdrawn, the murk is pressed, and the united liquids are placed in barrels to complete their fermentation. The barrels are pièces of 228 litres each, feuillettes of 114 litres, and quartants of 57 litres. The so-called great wines of Burgundy are produced in nineteen communes of the arrondissement of Beaune. We abstain from enumerating particular growths, as much abuse is practised with names. The best Burgundy wines are generally exported to Holland and Belgium, and the traveller in these countries may frequently obtain a bottle of good Burgundy when other wines are not to be had, or are of inferior quality.

We quote, after the late Dr. Druitt, some passages from Armstrong's 'Art of Health,' written about a hundred and fifty years ago, which are supposed to show how much Burgundy and other natural wines were esteemed

at that time. When speaking of wholesome wine, he praises

> "The gay, serene, good-natured Burgundy,
> Or the fresh fragrant vintage of the Rhine."

He further describes Burgundy as the drink for gentlemen, and port as an abomination:—

> "The man to well-bred Burgundy brought up,
> Will start the smack of Methuen in the cup."

The last line refers to the port wine imported into England under the Methuen treaty made with Portugal in 1703, whereby the wines of the latter country were favoured by a low import duty, whereas the trade in French wines was impeded by an import tax amounting to more than double of that imposed upon Peninsular wines.

Armstrong already reprobates the mixing of wine with brandy, which seems to have been at his time, if not a new, at least a newly-revived practice. In describing a man's sensations on awakening after having drunk port wine the evening before, he says:—

> "You curse the sluggish port, you curse the wretch,
> The felon, with unnatural mixture, first
> Who dared to violate the virgin wine."

Champagne.—The wine which from the country of its origin is termed Champagne, is one of the most essentially French inventions. It is so remarkable that a wit included it amongst the three inventions which alone were worthy of the powers of the human spirit, namely, foil-fencing, the Jesuits, and Champagne. It is made mainly from the same grapes from which red Burgundy wine is made, particularly from the black pineau. It is colourless, because it is fermented without the husks, whereas red Burgundy, like all red wines, is fermented with the husks. The culture of the pineau vines in the Champagne may be termed viticulture by constant rejuvenescence. The vines are every three years sunk into the ground, and one year's wood only is allowed to project from the ground and from the new

vine. This gives to the Champagne vineyards the aspect of constant youth, and much of the character of the wine is no doubt determined by this peculiar mode of growth. Harvesting and vinification in Champagne are very clean and perfect processes. The expressed juice of the grapes is fermented in casks. In ordinary years the whole of the sugar is fermented away, and yields about 8 or 9 per cent. of alcohol ; but in very good years a small quantity of sugar escapes this first fermentation, and remains in the wine, to yield, by a second fermentation in the bottle, the effervescence which is desired. The wine, which has lost all its sugar in this first fermentation, requires therefore an addition of sugar to it before it can acquire the *mousse* in bottle. Two fermentations, therefore, are required in the production of *mousseux* wine : one in cask, to decompose the bulk of the sugar and produce wine, and one of the young wine in bottle to produce effervescence. The process is exactly the same as that which leads to effervescent bottled beer, or cider, or perry, or gooseberry wine.

The particulars of the steps which lead to perfect *mousseux* are the following : The young wine is clarified with isinglass previous to its being drawn into bottles. Then the acidity and sugar of the wine are carefully adjusted, so that the former may not exceed a half per mille, the latter 2 per cent. This sweet wine, termed "clairet," is now filled into the ordinary bottles, and corked in the manner in which we see the champagne corked when it is quite ready for use. The bottles are stacked in rooms of rather a high temperature, and their contents begin to ferment, as indicated by their becoming turbid, and by a few bottles breaking here and there with some explosive violence. When this stage is reached, the bottles are carried to a cooler cellar, where they complete their fermentation and deposit the yeast. When the wine has become quite clear again, and all the yeast is collected on the side of the bottle, the latter is so manipulated that all the yeast settles in a small lump upon the cork. This has now to be removed by a skilful operation termed disgorging. The wires and

strings which hold down the cork are cut, and the cork is allowed to be expelled by the internal pressure, together with all the yeast and sediment. The loss of wine caused by this is filled up with some clear wine, and with a solution of sugar in wine termed "liqueur." For the wine, when disgorged in the effervescent state, is what is termed quite dry, that is to say, not in the least sweet, but tastes rather rough and unpleasant, from the mass of carbonic acid dissolved in it. The liqueur which is used for common wines contains also brandy and flavouring materials. The quantity of liqueur introduced varies between 10 and 28 centilitres per bottle of about 80 centilitres. For special, or so-called extra-dry Champagne, such as is preferred by some consumers in England, a lesser percentage is taken. The wine thus cleared and treated with liqueur is again corked, and prepared for sale in the well-known shape.

The manufacture of Champagne, though theoretically simple, is nevertheless a complicated mechanical operation, requiring above all cleanliness, skill, good taste, capital and good cellars. The latter, in the Champagne, are frequently dug into chalk rocks. Here the average temperature of the earth's crust nearly always prevails, and the wine, being never disturbed by fluctuations of temperature, attains that brilliancy which is the main cause and condition of its stability after disgorgement. The most dangerous and common disease of Champagne used to be viscosity or ropiness. Against this disorder, tannin from nut-galls, from catechu, or from grape husks and kernels, is used.

The wines of the Maconnais and Beaujolais districts are red and white. The red varieties are esteemed in France, as they are sufficiently coloured and acid to be suitable for being mixed with water for use at meals. The better varieties are heady in a manner which, according to our experience, is by no means explained by their alcoholicity only. Many of these wines are also manufactured into effervescent wines, including even red-coloured varieties. Much white effervescent wine is made upon the banks of the Loire, at Saumur, and sold at lower prices than Cham-

pagne of similar quality. Other parts of France, *e.g.* the Rhone valley, also furnish effervescent wines, all of which find their billets somewhere in the world.

Wines of the Gironde or of Bordeaux.—The Gironde is a beautiful and rich viticultural province, situated upon the lower reaches of the Garonne, Dordogne, and their estuary the Gironde. Its most valuable part is the Médoc, situated south-west of the Gironde, between it and the Gulf of Gascony. Here, on gravelly hills, grows that beautiful twin pair of vines, the carbenet sauvignon, and the carmenère. These vines are kept low on the ground, trained to espaliers not above a foot high. The tillage of the soil is mostly effected with the plough. The vintage is in September, and vinification is quick and simple, and is almost exclusively directed to the production of red wines. These are of very uniform character, though greatly differing in quality. They are divided into classified and non-classified wines. To the first rank of the classified belong those great properties termed "châteaus," from the habitation attached to them, under whose names so many substitutions take place. The details of these and the other classes may be read in works which treat of the Médoc, by W. Frank, by Cocks, or by Armailhac, or in the chapter of the 'Treatise on Wines' already quoted. The wines which do not belong to any of the five classes are termed "citizens" and "peasants." The first of these have again degrees of quality, namely: superior, good, and ordinary citizens, but the *paysans* are mostly held to be of one quality only.

Among cheap wines, those of Bordeaux are as a class tolerable beverages for the price, say at half-a-crown a bottle. Their alcoholic strength is mostly natural, and does not rise above 20 per cent. of proof spirit. They are perfectly fermented, and free from sugar.

Immediately surrounding Bordeaux is the district of the Graves, so termed, it is said, from its gravelly soil. It produces both red and white wines, of which the former resemble those of the Médoc. The white wines resemble

those of Sauterne, but are much less esteemed on account of a peculiar objectionable surtaste, which is termed flinty or earthy. To the south-east of the Graves, and bordering upon the River Garonne, is the district of Sauterne. Here all the hills and slopes are covered with the twin pair of vines, the semillon and the sauvignon. These grapes have the peculiar faculty of becoming very sweet without passulation, or shrivelling to raisins, so that, while yet plump, they yield a must which does not during fermentation lose the whole of its sugar, but remains sweet, and sometimes greatly so, without the addition of any spirit. The collection of the grapes is effected in several stages, so that three qualities of wine are produced from the same vineyard. The finest and ripest berries yield the wine called head, *tête*, a sweet liquorous wine, which is consumed principally in Russia. The second quality, or the less saccharine berries, yield a wine which after fermentation contains no sugar, and is termed the middle, *milieu*. This is Sauterne, commonly so called in England. All the grapes which have not been used for the former two qualities are thrown together, and the wine made from them is termed tail, *queue*. When the three varieties of wine are mixed, the result is called *ensemble*. The production of sweet wines for Russia has depressed all qualities of dry Sauterne. On the right bank of the Garonne there are extensive vineyards producing red wines, which are exported from Bordeaux under the name of the town. They have no great peculiarities, and are therefore frequently mixed with some Médoc wine, and exported as such. On the low marshy ground is the peninsula formed by the confluence of the Garonne and Dordogne, which is termed *Entre deux mers*, large quantities of wine are grown. They are termed marsh wines, *vins de palus*, and in warm years attain considerable quality. But the viticulture of this district is mainly intended to produce quantity, and this is attained by the cultivation of medium-sized grapes, such as the verdot and the merlot, on espaliers which allow to each vine two or three tiers of bearing branches.

To the north-east of the Garonne are yet some districts which produce much wine: those of Libourne, St. Emilion, and the hills along the banks of the Garonne called "Côtes." The St. Emilion wines are fine, but thinner and paler in colour than the Médocs. The wines of the Côtes are white; they are eagerly bought by the Bordeaux trade, mixed with deep-coloured wine of Narbonne, and sold as red wine to Transatlantic markets, sometimes at such low prices as 9*s.* the dozen, cases, bottles and corks included. In purchasing Bordeaux wine it is advisable to disregard entirely the names, which dealers affix to bottles, and simply to select the wine according to taste and value intended to be expended.

Wines of Germany, Austria, and Hungary.—The principal wine-producing districts of Germany are the valleys of the Rhine and its tributary rivers. Austria also produces some wine, of which a small quantity is exported, notably wines of Vöslau. Rhine wines are characterised by a peculiar bouquet, the product of the Riessling grape. About half the vines in the Rhine valley consist of Riessling plants, and it is probable that this vine is indigenous to the Rhine valley. In the Palatinate the Riessling is frequently accompanied by the Traminer. The third variety of vine frequently grown on the Rhine is the Sylvaner, or Austrian. These three vines give, the first highly-flavoured, the second round bodied, the third spirituous wine, and in given cases the mixture of the fruit of the three produce an excellent wine. In Baden much wine is made from the Chasselas, there termed Gutedel. The black or blue varieties of grapes grown on the Rhine are all descendants of the Burgundy pineau. Ingelheim and Asmannshausen are the centres of their production, of which much is now used for the manufacture of effervescent wine. The wines of Alsatia are nearly all white and genuinely German, and are much used by the Swiss. The Palatinate produces about 800,000 hectolitres of wine. The wines of Rhenish Hessia are similar to those of the Palatinate on the one hand, and those of the Rhinegau on the other.

The vineyard south of the Liebfrauenkirche at Worms produces the "Liebfraumilch," a Riessling wine of some bouquet. The wines of the Maine are mostly very acid, Stein and Leiste excepted; Stein is sold in peculiarly-shaped bottles called "bocksbeutel;" much Palatinate is sold under this disguise. The Rhinegau, a district north of the Rhine from Hochheim to St. Goar, produces the finest wines in Germany. The entire Gau produces in good years about 10,000 stück, equal to nearly 20,000 butts, or four-sevenths as much wine as the sherry district proper. With regard to hock it is also advisable never to listen to a name, as these are frequently used with the same disregard of truth as the names of the Médoc. Sparkling hock finds much favour in this country, and with regard to this the playing with names has been abandoned. The Moselle wines are mostly lower-class wines, and possess as little flavour as the Franconia wines, but are made with much more care. Sparkling Moselle is a nice product of art, and derives its conventional flavour from the elder flower. The white wines of the Rhine are distinguished by never containing added distilled spirit; they are never coloured, plastered or boiled; and in these respects are equal to the best produce of the Gironde. For these reasons they are equally wholesome to drink; they produce none of the inconveniences of the brandied wines of Jerez and Oporto.

Tyrol, *Styria*, *Dalmatia*, and *Croatia* produce much wine, but it is mostly so badly made that it finds no consumption except in the localities. The vines of Istria and Görtz are grown much like the Italian vines, high in the air, and their product is without quality.

Hungary produces much wine of a low class; viticulture is very imperfect, the treatment of wines in the cellars very bad. Only some wine-merchants treat a certain portion of Hungarian produce with the skill necessary to make it a commercial article. There are two dominant vines peculiar to Hungary, the Furmint or Tokay, with white grapes, and the Kadarka with black grapes. The Furmint is sweet and strong flavoured; it becomes passulated on the vine;

it is from such raisins that Tokay essence, Ausbruch, and Maszlacz are made. These wines are syrupy, unfermented or little fermented. The fully-fermented Tokay is termed Szamorodny. Rust and Menes wines are made similar to those of Tokay; the most celebrated Tokay, therefore, is not properly a wine, but a highly concentrated grape-juice, in which alcohol is not essential to preservation, and is mainly an accident of some slight fermentation, which occurs slowly during the keeping of the wine. Old Imperial Tokay contains so much grape-sugar that it forms sometimes a sediment of crystals in the bottle. We have an exact counterpart to Tokay in the tintilla de Rota, which is made at Rota on the Gulf of Cadiz. This tintilla is also mere juice of raisins and boiled must, and is not intended to ferment or contain alcohol. But it sometimes does ferment slowly and slightly, and forms up to six per cent. alcohol. Latterly, however, both Tokay and tintilla are not rarely mixed with spirit, and have thereby become changed, and as we think, lost in character.

Wines of Spain.—Spain produces a great variety of wines from the worst to the best, red and white, dry and sweet; it has even been attempted to produce effervescent wine in that country, but the attempt failed, from the same disregard of the principles of œnological science which causes so much wine to be spoiled either by diseases peculiar to southern climates, or by brandy and plaster. The most beautiful vineyards of Spain, perhaps of the world, are those of Jerez de la Frontera, near Cadiz; they are situated on undulating hills, and in gentle valleys between them; the hills consist of tertiary limestone much mixed with clay and sand; the white clayey limestone, albariza, gives the best soil; the second best soil, consisting of quartz mixed with limestone and sand, and coloured by ochre, is termed barros. The vines grown in Jerez are all large-berried and large-bunched, such as only ripen in the very hottest climates out of the tropics. Most remarkable amongst them are the palomino, which is most frequently cultivated on the albariza soil; the mantuo castellano, which prevails on the sandy barros

territory, and the Pedro Ximenes, which is grown on any soil for its great sweetness. The climate of Jerez is characterised by great heat and long-continued drought; autumn and winter consist of a rainy season; snow has fallen in Jerez only twice during this century. The labours in the vineyards are all performed by men, and are very important and severe. Thus in autumn each vine is surrounded by a square excavation and rampart, whereby the water is collected and compelled to sink into the ground. This process amounts to a real flooding of the vineyards; besides its main object, the thorough moistening of the land to enable vegetation to survive the rainless season, this practice attains the destruction of all vermin, so that the phylloxera can never live in a well-treated Jerez vineyard. The vines are kept quite low on the ground, and receive no supports; only the branches bearing nearly ripe fruit are slightly raised from the ground by short forked supports of reeds. The vintage begins about the 8th of September, and ends about the 20th. A vineyard of about an English acre in area, if of albariza, will produce from $1\frac{1}{2}$ to 2 butts of wine, if the soil be dark or sandy from 4 to 5 butts. The Jerez vineyards produce about 36,000 butts of wine of all qualities each year. The grapes are spread on the platform bearing the press (lagar) and dusted over with plaster of Paris; they are next trodden and pressed; the resulting grape-juice or must is not more saccharine than that of any of the principal vineyards of France or Germany. As the average of more than a hundred experiments, I found the specific gravity of the must to be 12·39° Baumé. This would yield a wine with about 22° of proof spirit. Fermentation is conducted as rapidly as possible; the wine when clarified is racked, and now has about the same alcoholicity as other wines, *i.e.* from 18° to 24° of proof spirit. Brandy is now added at once to it, so as to withdraw it from the influence of a second fermentation, and of the principal abnormal ferments or so-called diseases, which, under the name of nube, scud, or viscosity, are known to spoil so many wines either for a time or for ever.

In its natural state Jerez wine ripens quickly, but the addition of brandy retards its maturation, and alters its character. It is owing to this that sherry is rarely obtained by the consumer in anything like a natural state. Not only is more brandy added to all varieties, but some qualities receive an addition of boiled must, or must concentrated to the state of a syrup, *arrope*, and then mixed with spirit, so-called *vino de color*, and others receive, besides arrope, an addition of the juice of sun-dried raisins preserved in spirit, so-called *dulce*. (Of this we have treated under the paragraph referring to liqueurs.) These processes produce a compound brown sherry, which is wine only in part, and is found to be less wholesome than the simpler vinous beverages. Pale sherry is a purer wine, if not blanched by animal charcoal; the principal objection to it is that it is still plastered and brandied. The principal effect of the plastering is that the wine has lost its natural tartaric acid, and has become impregnated with sulphuric acid, which remains combined with the potassium from which it has displaced the tartaric acid. Sherry therefore contains sulphate of potassium instead of the tartar which it ought to contain, and this anomalous ingredient causes to delicate constitutions inconveniences in the functions of digestion and circulation, which compel them to abandon the use of sherry. Some common qualities of sherry contain much more sulphuric acid than can be introduced by the process of plastering, and this is introduced as sulphurous acid or brimstone vapour after the must has been pressed. This latter acid remains to some extent in the free state, or becomes in part sulphovinic ether after a long time, while the acid introduced in the process of plastering remains combined. Thus we can understand why some descriptions of sherry should contain from three to five pounds of sulphuric acid per butt. In return for the unquestionable disadvantages of this practice, there must be conferred by it, we are ready to assume, some advantages, which the viticulturists obtain without being able to define them. We believe the principal advantage to be the removal of tar-

taric acid at a period when it can serve as food to the viscosity or scud bacterium; this fungus decomposes tartaric acid so as to liberate some acetic acid, and this just spoils the finesse and flavour of the wine; this development of acetic acid from tartaric must not be confounded with the development of acetic acid from alcohol under the influence of the vinegar fungus. The absence of tartaric acid from the sherry does not protect it from the inroad of the scud or viscosity fungus, but only from one of its casual effects; the other effects of viscosity or scud mostly remain in one shape or another, which may be summed up as general deterioration of the wine. We thus perceive that a fungus, by the ruinous changes which it is capable of producing in young wine, is the cause of the proceedings intended to avoid these changes, namely, plastering, sulphuring, and brandying. It remains to the future to supplant these primitive processes by better precautions, and to restore to sherry that natural beauty, purity, and vinosity, by which it would excel all other wines of the world. Sherry, during maturation in casks which are not quite full, so that air has constant access to a considerable surface of wine, is liable to undergo an advantageous development by the formation on its surface of a kind of fungus termed flor; it assumes a taste which forty years ago was considered to have spoiled the wine, but is now highly valued, namely the so-called taste of amontillado. This change is as yet a matter of mere accident, and cannot be produced at the will of the wine-producer. Only a small number of casks become amontillado, while the great number remain indifferent wine, or become sick, or spoil altogether. The average price of freshly-fermented wine, so-called *mosto*, at Jerez is about £12 per butt, but good amontillado, or *fino*, fetches several times that amount, and, after adjustment for the wants of the trade, is sold at high prices.

In Jerez, and generally in Spain and Portugal, there are no cellars, the wines are always made, fermented and kept in buildings above-ground, constructed for the purpose—

mere sheds, termed in Spain bodegas, in Portugal adegas These sheds are subject to all the variations of temperature of the air, and the wine in cask is constantly influenced thereby. Under these conditions wine would necessarily soon become vinegar, were it not heavily brandied. We thus see that not only fungi but also bodegas are amongst the causes which either spoil the wine in their own way, or cause it to be spoiled in a particular way by the additions necessary to prevent spontaneous decomposition.

The vineyards of San Lucar de Barrameda are situated on albariza hills near the mouth of the Guadalquivir. The wines are mostly listanes, the same as are termed palomino at Jerez. Vinification is the same as at Jerez; plastering, vino de color, dulce and brandy are used to make up the semblance of sherry. But there is a specialty produced at San Lucar, which may be termed the parallel to the Jerez amontillado, namely the so-called manzanilla de San Lucar. This wine has a particularly nice, though thin flavour, while young; with age it becomes very dry and somewhat bitter. It has the character of all wine made from somewhat under-ripe grapes, and becomes passado at less than one-third of the age of genuine sherries. The manzanillas de San Lucar are generally sold at less than half the price of Jerez wines, and, like them, they are always suffocated in spirit before shipment.

Rota, a village on the north side of the Gulf of Cadiz, produces, on sandy soil, some varieties of viticultural products, of which the tintilla de Rota is the best known. It is a syrup made from passulated grapes by maceration with must concentrated by heat; it ferments a little, so as to form about 12 per cent. of proof spirit, and thus acquires some vinosity and flavour; it is an agreeable sweet liqueur, but it is now frequently spoiled by dealers adding brandy. Wines of the Val de Peñas are imported into England at the almost natural strength, containing less than 26 per cent. proof spirit; they are both white and red, and of good quality at their price.

Catalonia, Aragon, and *Valencia* produce some beautiful wines. Red Catalan, sweetened and brandied, is now imported into England under the title of Spanish port. The Valencia wines are perishable, and have no great reputation except for distilling brandy from them. Alicante is distinguished by producing in great perfection the vine which bears the name of the town throughout Spain and the south of France, but at Alicante itself is termed tintilla; its juice forms the basis of most Spanish red wines. Granada also produces a few thousand butts of wine, of which those produced at Malaga are the best known; they are mostly exported to America. The wines of Catalonia, Aragon, and Valencia, white as well as red, are almost all plastered, and several Spanish œnologists have strongly protested against the practice, which they term an adulteration and a fraud. Some wines are accidentally plastered by being kept in underground cisterns of masonry, of which the building and lining material is plaster of Paris; the stones also are gypsum now and then, and stones of gypsum, gathered from the fields, are not rarely used to keep the murk submerged in the fermenting wine. It is likely that the practice of plastering arose out of some such accidental observation.

On the whole the wines of Spain are by nature generally excellent, but are easily and quickly spoiled, in part by diseases, in part by unskilful and unscientific treatment. The admixtures effected to counteract these accidents are more or less objectionable, because unwholesome to the consumer. It ought therefore to be impressed upon œnologists that if they desire to see their industry rise from the depression from which they complain that it suffers, they must prepare natural pure wines, and avoid the accidents and admixtures described in the foregoing.

Wines of Portugal.—The principal wines of Portugal are those grown in the Alto-Douro district, and exported from Oporto, and hence termed port wine. The district is a mass of rough mountains formed by clay schist, similar to the Grauwacke of the Rhine valley. It is the vine, and

the vine alone, which has made the Alto-Douro a cultivated part of the earth's surface. The vineyards are constructed with so much labour in the face of so many difficulties, that they may appropriately be termed "the vineyards of Hercules," while those of Jerez, owing to their soft undulating beauty, deserve the name of "the vineyards of Venus."

The district between Oporto and the Alto-Douro is the province of Entre Douro e Minho, and is remarkable on account of the many semi-wild vines which grow here upon trees, and furnish the material from which the natives produce an awful drink, termed vinho verde.

The vineyards in the Alto-Douro are all arranged in terraces constructed with stones. Sometimes a mountain side may bear as many as one hundred and fifty terraces and walls. The Douro vines have this peculiarity in common, that their fruit is not large-sized like the grapes of Andalusia, nor small-sized like the grapes of Burgundy or the Rhine; but medium-sized like those of the paludal or Sauterne vines of the Gironde. The Verdeilho yields a fine peculiar wine; the Mourisco gives a very sweet wine, with much body and colour; the Bastardo produces fine wine, but with little colour. The vintage takes place between September 20 and October 10; that is to say, as late as is compatible with the safety of the crop, in order to let the juices become as concentrated as the sun will make them. The vintage labours, as indeed all the vineyard cultivation, are effected by workpeople of both sexes from Gallicia, hence termed Gallegos. The grapes are trodden by men on platforms, and the murk and juice are removed to stone-built vats, lagares. When the fermentation has so far proceeded that the amount of alcohol formed has dissolved all the available colouring matter, the mixture is agitated, and the wine drawn off. The mixing and agitating is effected by men standing in the vats. These act as living stoves to keep the wine up to the fermenting temperature in cold weather. In good years, when the wine contains more sugar than can be decomposed by a first fermentation, the addition of brandy to newly drawn

wine completes the first preparation; but in years in which sugar is deficient, this as well as alcohol have to be supplied. Sweetness is supplied frequently in the shape of concentrated grape-juice preserved in spirit; this is called jeropiga. Port wine mostly contains so much colouring matter that it can bear the addition of white jeropiga; it very rarely will require increase of colouring matter, so that the stories about elderberries in port wine do not seem to have much foundation in fact. These wines are never plastered, and the only extraneous addition which all of them receive is brandy. The minimum is three gallons to the pipe; but the so-called rich wines contain from fifteen to seventeen gallons of adventitious brandy in each pipe of 115 gallons. Thus dosed up to 40 per cent. of proof spirit, port wine becomes undrinkable for many years; but keeps. Port wine with less than 34 per cent. proof spirit, is liable to undergo a second fermentation, and to deteriorate by acquiring an acid flavour; but with proper arrangements port wine of natural strength can be made and preserved, and this is a fine, dry, full-bodied, full-flavoured beverage, which is more like the finest Burgundy than like the manufactured traditional hot and sweet port; but has a bouquet which is quite unique. Such a wine, which we examined, showed only 14·91 per cent. of alcohol by weight in volume of wine, therefore only about two-thirds of the alcohol contained in ordinary varieties; of this, from 1 to 2 per cent. was probably added. Perfectly natural port wine has 9 per cent. as the lowest, and 13·8 per cent. as the highest limit of alcoholicity, therefore, the same as Médocs, Burgundies, hocks, and sherries.

Genuine port wine is easily recognised before the spectroscope by a single absorption band overlying the D-line. Elderberry juice, on the other hand, has four absorption-bands, one in red, a broad one in yellow and green, and two in blue.

A low-priced, natural, dry, red wine, termed consumo, meaning a wine for ordinary use, grown in the Douro

valley, is now imported into England; it contains only 10·91 per cent. of alcohol, and thus keeps close to, but slightly above the full quantities of Burgundy. A variety of port was formerly made from white grapes, and much favoured in Ireland. But it is rapidly going out of use there, as elsewhere.

Other Portuguese wines are those of the neighbourhood of Lisbon, which are mostly sugared and brandied; those of Bucellas, made from the Arinto grape, supposed to be identical with, but probably only resembling, the Rhenish Riessling; those of Carcavellos: the last two wines are almost traditions only, as the vineyards are almost entirely destroyed by the oidium. Much red wine is made in the Torres Vedras valley, and all exported to France to be sold as Bordeaux wine. Collares is grown below Cintra, and is mostly consumed at Lisbon. The rest of Portugal is teeming with wine; but it is so badly made that it is unfit for trade. The Government of Portugal has, however, taken great pains to spread information amongst the cultivators of the soil, to improve vinification; and the reports of their commissioners are most important documents in the history and literature of œnology.

Wines of the Atlantic Islands.—Madeira is an island of tertiary limestone, overlaid by the eruptive products of an extinct volcano. The vines here cultivated came from Candia; most important is the so called malvasia, which yields the best Madeira wine so called; the vidogna is, perhaps, cultivated on a larger area than the malvasia, it is similar in appearance to the chasselas, and yields dry Madeira. But the vine prevailing in the new plantations is the verdeilho. The vines are mostly grown high on espaliers. The grapes are trodden and pressed, and the must is fermented in barrels. It is then racked, mixed with brandy, and matured in magazines which can be heated to 140° Fahrenheit, so called estufas (stoves). Unfortunately the wine is not always heated early enough, so that much of it retains traces of the diseases to which it is liable, particularly scud, viscosity, and mouse-taste. Most

Madeira is dry, *i.e.*, free from sugar; the sercial grape imparts to it some astringency, and with it lasting qualities; it can therefore be preserved with less brandy than sweet wines. Before 1852, Madeira produced 20,000 pipes of wine annually; between that year and 1857 all vines were destroyed by the oidium. In 1878 about 13,000 pipes are stated to have been produced; but the exportation in 1881 had only risen to 3,447 pipes.

The Canaries are a group of seven islands, the principal of which is Teneriffe. All have volcanic soil, and produce wine from the malvasia, vidogna, and verdeilho grapes. Canary sect of former times is said to have been the sweet white wine of these islands, "vino secco," or "seccato," so called because it was made from grapes which had been dried or passulated to a certain extent before vinification.

The Azores produced about 5,000 pipes of wine annually; the present production is small. Most of the wines from the Canaries and Azores are vatted with and sold as sherry.

Wines of Italy.—A great variety of wines is produced in Piedmont. Those of Asti and Chaumont have acquired a reputation. We have obtained a number of wines from Turin; but found that the effervescent ones (spumantes), all became viscid, and formed furs of fungi in the bottles, while the red ones were all in a state of fermentation, and, when this was over, retained a peculiar biting taste not dependent upon carbonic acid. Grignolino, so called from the grignoli grape, a relative of the carmenet of the Gironde, seemed to us to have a future, provided it were prepared with scientific accuracy.

The best Italian wines are produced in Tuscany. Of vines, the aleatico, or red muscat, is extensively grown at Monte Pulciano, between Sienna and Rome, and other places. The wine is liquorous, purple in colour, sweet (extract rising to 21·88 per cent.) and slightly astringent. A good red wine is made at Chianti, near Sienna, from a peculiar grape. The nobles of Florence, like those of

Vienna, sell their wines in retail from their palace cellars, in flasks of the shape of the well-known oil-flasks, containing about three quarts each. These bottles are not stoppered; but the wine is covered with a small quantity of oil, which is removed before the wine is poured out The wines of Lombardy and Venetia are common and unfit for export. Central Italy produces the wine of Orvieto, and the liquorous muscats of Albano and Montefiascone. Of South Italian wines, those growing round Naples have alone some quality. On the whole, wines in Italy are badly grown, badly made, and strangely flavoured with resins and extracts. But Sicilian wines, which are reared by English enterprise, are remarkable for quality and low price. Only one variety is exported in large quantities, namely, the light amber or brown wine which goes under the name of the town from which it is exported—Marsala. It is situated near the western termination of the northern coast of Sicily. The vineyards extend along the coast towards the east and west, over an area of upwards of twenty square miles in length, by twelve in breadth. The soil is a chalky clay. The varieties of vines are many, and the grapes are all of inferior quality. All the wine shipped from Marsala to England is strongly brandied. Much of it is sold as such; but large quantities are transformed into sherry so-called. The total quantity of wine grown in Sicily is not known; less than 300,000 gallons of it are consumed in England.

Wines of Greece.—The Kingdom of Greece and the Greek islands of the Mediterranean sea are very favourably constituted for the production of wine; but the opportunities are not made use of so successfully as could be wished. The production of wine, which was considerable at the time of the Venetian supremacy, has sunk to a relatively insignificant amount. Most of the vines are cultivated for the production of currants; the principal variety producing them is termed *Vitis Corinthiaca*, also called *apyrena*, the stoneless, and, from its product, *Uva passa*. Another Greek vine is the Greco, a third the Cipro. The most

important vine for the small islands seem to be the assyrticon, which forms the great majority of the vines of Santorin. It would be impossible to enumerate the various Greek wines made; they are mainly used in the locality, or exported to the East, latterly also to France. Some are of good quality originally, but are spoiled by bad management. The so-called Hambro, or Elbe sherry, is made from Greek wines, both dry and sweet, exported by a German company from Patras, in English ships, to Hamburgh, and there mixed with refined potato spirit; the coloured and flavoured preparation is superior to sherry in this particular, that it is not plastered; but it only ranks with the lowest sherries in price, as it possesses only little vinosity. The wines described by various travellers are interesting, and may in the future obtain the mercantile success which they deserve.

The wines of Cyprus are of two kinds, fermented and liquorous. The Commandery wine is made in vineyards near Paphos, in the district of Orni. It is fermented and matured in about 40,000 earthernware vessels, of the ancient shape of amphoræ, of which each holds from 10 to 12 litres. The wine is of a dull colour, and becomes tawny by age; it is a little sweet, with an astringent taste, and a peculiar flavour, reminding of bitter almonds, and supposed to be imparted to it to a certain extent by extraneous spices. It is still mainly consumed at Venice and Livorno.

In *the Crimea* much good wine is made, partly on the Imperial Russian estates, partly in vineyards belonging to private persons or companies. The products are consumed in Russia, and form no article of Western trade.

Asia produces splendid grapes, and in some parts of its vast expanse excellent wines, *e.g.* at Schiraz. As they are at present prepared, they do not suit the European taste. The wines of Schiraz are sold by weight. A Persian proverb considers them essential agents of happiness: "Who will live merrily should take his wine from Schiraz, his bread from Yesdecast, and a rosy wife from Yest."

Some Schiraz wines travel as far as Hindostan, China, and Japan.

Africa produces wines in various parts. The best known are those of South Africa or the Cape of Good Hope. The vines grown there were all imported from Europe about 1650. Fully fermented wine is made from the black Burgundy, and the Riessling grape; but the constantia, a liqueur wine, is made from the muscat of Frontignan.

Madagascar possesses an indigenous vine which the inhabitants declare to bear poisonous fruit.

In *Morocco* and *Algiers* excellent grapes grow, and some wine is made. In Algiers viticulture is expanding; but in Mahommedan lands it meets with many difficulties.

In *America* many indigenous vines have been discovered, and cultivated either as found, or after crossing with other varieties. The most remarkable of these are the Catawba, the Cape grape, the Isabella, Bland's Madeira, Ohio, or cigar-box grape, Lenoir, Missouri, Norton's seedling, and Scuppernong. From the black Catawba an exquisite effervescent wine is made, which has a most characteristic bouquet. Of this, about 200,000 bottles are annually produced. The wines from the other varieties are in course of development. Cincinnati is the centre of viticulture in North America.

Wines of Australia.—Viticulture was begun in Australia in 1830, and is now of some importance. It is said that most of the wine-growers in that colony are gentlemen of property, who are desirous rather of producing fine and creditable wines than of obtaining large or immediate profit. The effect of this interest taken in the subject by a few respectable growers must be to establish the character of the wines, and render their production a permanent and remunerative interest. New South Wales, South Australia, and Victoria, all produce wines, which are mostly fully fermented; some are a little brandied; some are prepared as liqueur wines. A few varieties are imported to and sold in England.

BRITISH OR DOMESTIC WINES.

When we speak of British wines, we thereby signify fermented liquids made after the manner in which wine is made in viticultural countries, but with fruit juices other than that of fresh grapes, or with saccharine matters derived from other parts of plants, or from animals. Before the reduction of the wine duties in 1860 much wine was made in this country from imported fresh grapes, and at Reading, *e.g.*, there existed a manufactory owned by an intelligent and enterprising French wine-cooper, where genuine black Burgundy or Champagne grapes, imported from France, were transformed into wine, and this ultimately into Champagne. Similarly, London wine-makers made Champagne at their British wine manufactories. These effervescent wines differed from genuine Champagne only in this, that they were manufactured in England, but in all other respects they were genuine wholesome wines, of fair quality at their price. This manufacture was profitable as long as the heavy import duty on French wines was levied, but ceased to be so as soon as natural wines could be imported into this country at the import duty of 1*s.* per gallon. Fresh grapes continue to be imported into this country for the production of British wines of various qualities. They serve, however, mainly as the ferments of larger quantities of saccharine matters, mostly cane-sugar, and the products are, as far as we are aware, mainly sweet wines, some being flavoured with aromatics, spicy, or bouquet-imparting ingredients, without addition of spirits, while others are mixed with spirits and coloured, so as to resemble common varieties of port and sherry. We cannot exclude the latter from notice, although we do not approve of imitations of any kind. But most of the British wines which we shall have to notice are so peculiar and so good, so original in their taste, when properly made, and owing to their cheapness so useful to many classes of the people, that we think it just and patriotic to put their merits properly before the public in these pages.

*Apple Wine or Cider.**—This beverage is made in considerable quantities in South Germany, Brittany, and several counties of England: Gloucestershire, Worcestershire, Monmouthshire, Devonshire—more particularly Herefordshire. In the latter county the apples which are more particularly suitable for the production of cider bear the following names: Foxwhelp, Skyrmer Kernel, Red Must, White Must, Styre, Red Streak, Kingston Black, Royal Wilding, Golden Pippin, and Woodcock. (Dr. Robert Hogg: communicated to the author on the occasion of the Apple Congress at the Royal Horticultural Society's Garden at Chiswick.) These apples are not often fitted for the table. They are required, says Booth, to be juicy, of an acid, tart, and aromatic flavour, with a certain degree of astringency. (Cf. Knight, on the 'Cultivation of Apples and Pears.') The Styre or Stire apple is, however, a tolerably good eating apple, while it is esteemed far superior to the other cider apples. Stire cider frequently fetches four times the price of common sale kinds. Coccagee cider is famous in Devonshire, and in this county the farmers are said to have a belief that the finest old fruit-trees were originally brought from Normandy; but the varieties are many of them kernel-fruit, that is fruit from seedling stocks which have never been grafted. Of these Marshall, in his 'Rural Economy of Gloucestershire,' 1789, speaks with enthusiasm of the Hagloe crab, which would appear to be superior even to the Stire. In general practice, cider is made from a mixture of apples which ripen at the same time. Some make their cider from apples and pears jointly, and others from sweet apples mixed with common wild crabs; but these are chiefly for home consumption, where what strangers would term insufferable harshness is accounted a good property. The rough cider of the farm-house is a beverage against the use of which the urban palate rebels.

* Cider, Fr. *cidre;* Arm. *cistr;* ciderist, cider maker or seller; ciderkin, the last pressed, or poor cider. Stum: must, or unfermented wine; also new unfermented wine, which is poured to old. To stum: to pour new must to old wine, to sulphurise.

The apples must be carefully gathered, without being bruised, during dry weather. They are then put in heaps of ten or twelve inches thick in the open air, exposed to the sun and rain, and uncovered, except in severe frosts. In these heaps they are left to mellow, that is to say, to increase in sugar and decrease in acidity, and acquire the highest possible flavour. They show the state of perfect ripeness by the deepest yellow colour which can be acquired without discoloration of the rind by decay. All green or decayed apples are picked out and removed.

The apples may now be pounded with wooden pestles, covered with nails (Cornwall, Ireland), or they are crushed under a stone, which is moved in a semi-circular or circular trough by human or animal power. Such a trough is fed with about two bushels of apples at a time. The ground apples are termed pommage. A man, having a female or a boy to assist him, usually grinds, with one horse, between two and three hogsheads of pommage a day, whereas with the hand-mill, which is much in use, three men can scarcely make a hogshead.

The pommage is allowed to rest about twenty-four hours, and is then pressed in the cider press. The pulp is wrapped up in hair-cloths, which are folded up square. They are laid one upon the other to the number of ten or twelve, and then pressed: slowly at first, strongly afterwards. On an average two hogsheads of fruit yield one of juice. The specific gravity of this varies between 1040 and 1060, which is equivalent to from 14 to 21 lbs. per barrel, as weighed by the brewers' saccharometer. The use of this instrument has not yet penetrated to transactions in cider-juice between farmers and dealers. The cakes of pressed pulp, provincially called cheeses, are re-ground with water, and these washings, as they are called, are again pressed, and yield a weaker must, which is fermented apart for the use of the servants. The fruit sufficient for three hogsheads of cider is generally allowed to make one hogshead of washings. These washings show nearly the same specific gravity as the original must.

The turbid must is placed in barrels for fermentation. The barrels are mostly made bung full ; some, however, leave some ullage. The thermometer is not used to watch the fermentation. The manufacturers of sweet cider endeavour to check the fermentation as far as they can by exposing the cask to the cold open air (Knight). If the fruit be imperfectly ripened, and the weather warm, fermentation will commence in less than twenty-four hours, while with ripened fruit and juice of great gravity it will occasionally remain without any appearance of change for a fortnight, especially in cold weather. If the must be now racked from the lees, and sulphured, fermentation will be at a minimum ; and if this process be repeated, a sweet liquid with little alcohol will be obtained. In some parts of Normandy, the juice, after having undergone for about three days a tumultuous fermentation in large tuns, is drawn into casks, and then left to complete its fermentation without further racking.

The casks are now and then filled up during the winter. In March the cider is mostly found clear and fit for being racked. Now the ciderists mix the wines of various colours, to produce uniform products. The highly-coloured cider made from the Jersey, or the luscious sweet apple, is mixed with the pale-coloured cider from the poor or sour apples. After this spring racking and mixing, the casks are bunged and laid to rest in a cellar. Cider which remains turbid must be fined with isinglass or with blood. The latter finings make the cider very pale, so that it is desirable to colour it again by caramel. Rarely the cider remains sufficiently sweet to please the palate, particularly of the London public ; it is therefore mostly made sweeter by the addition of sugar syrup.

It has been proposed to reduce the acidity of apple must by the addition of water and sugar, say to one volume of must, according to its acidity ; one volume or two or three volumes of sugar solution containing 20 per cent. of cane sugar. The addition might be regulated, so that the product should contain from 2 to 3 per mille of acid.

Such a product would, however, be different from natural cider or apple wine, and particularly would be much more alcoholic. This would be favourable to its keeping qualities, but involve a different use by the population.

Apple wine contains alcohol, sugar, pectin matters, gum, glycerine; of acids, malic, tartaric, amaric, acetic, tannic, oxalic, succinic, lactic, mineral matters, and ethers, which latter form the bouquet. Malic acid predominates over all others. French and English apple wines contain on an average—alcohol, 5·35 per cent.; malic acid, 0·342 per cent.; acetic acid, 0·111 per cent.; sugar, 3·27 per cent.; extractives, 4·75 per cent.; ash, 0·26 per cent.; its specific gravity is 1·0118. Swiss apple wine gave 7·35 per cent. alcohol, 0·57 per cent. malic and acetic acid, 1·85 per cent. sugar, 3·53 per cent. extractives, and 0·43 per cent. ash. Apple wine contains more calcium than grape wine.

In Devonshire a spirit used to be distilled from the fermented must, and the grounds and lees of cider, by means of a porridge pot, with a tin head over it, and communicating with a pipe passing through a hogshead of water. It was drunk in a recent state under the name of "necessity," and was considered to be more particularly the remedy for colic brought on by the inordinate use of rough cider.

Perry.—Perry is wine from pears, and is made in Herefordshire, Gloucestershire, Worcestershire, and Monmouthshire. The pears selected must possess some degree of astringency (according to Knight, 'On the Cultivation of Apples and Pears'). This quality is so necessary, says the author, that he never knew a single instance in which perry made from fruit without astringency did not become sour before the middle of the succeeding summer. Pear-juice, which does not naturally contain astringency, may have it imparted to it by admixture of some juice from the crab-pear. The pear preferred in Herefordshire is the squash-pear, which, according to Marshall's 'Rural Economy of Gloucestershire,' 1789, "has probably furnished this country with more Champagne than was ever imported into it." It

is described as remarkable for the tenderness of its flesh, which bursts if the fruit is allowed to fall ripe from the tree.

Two hogsheads of pears yield about $1\frac{3}{10}$ hogsheads of juice. The fruit is ground and pressed in the same manner as the apples, but the pulp is usually taken directly from the mill to the press. The management of the liquor is more precarious, so that good perry is always higher in price in the London market than cider.

The tumultuous fermentation is not so marked in pear-juice as in apple-juice, for the cider-juice carries a head, whereas the perry presents little or no scum, and remains more or less muddy when the first fermentation is over. The after fermentation is prevented by racking, sulphuring, and particularly fining with isinglass. Perry is liable to mishaps during the first summer of its existence, and to avoid these the casks containing it were not rarely bound strongly with hoops and ropes, and sunk in a deep pond. Late in autumn the casks were raised, and the perry was now found clear and effervescent.

Besides great astringency, the pear-juice to be used for perry must possess much saccharine matter ; while the fruit yielding it cannot be eaten, the juice once pressed becomes agreeable to the palate by the influence of mere contact with the air. It contains much less malic acid than apple-juice, but more sugar and tannin. Good perry is much more similar than cider to the white wines of the grape. It is said by Booth that, without any mixture, good effervescent perry has often been mistaken for the best quality of effervescing Champagne. An amateur, quoted by Booth, advises that the pear-juice should be concentrated by heat, during several hours, at 160° to 200°, while the feculencies as they arise should be skimmed off. The juice is now to be transferred into a wooden vessel, and allowed to cool to between 110° and 130°. It is then to be racked off, and to undergo a second coction ; and, if the harshness is not then completely gone, a third coction is to take place. The must, thus purified and concentrated, is to be put into a

cask, bung uppermost, but not quite full. It should then be bunged up close, while a peg-hole should be left for the escape of gas. The fermentation sets in quickly, and becomes tumultuous, on account of the warmth of the liquid and the great amount of sugar. The silent fermentation which succeeds produces a clear and strong perry, which has the advantage of keeping, and of improving with age.

A pear-tree in Herefordshire is recorded to have attained the circumference of 18 feet, and to have yielded 7 muids (French) of perry annually. The ancients knew perry as well as apple wine, as is evident from the passage of Pliny (lib. xiv., c. 19): "Vinum fit e pyrorum malorumque omnibus generibus."

Raisin Wine.—Macculloch, and after him Booth, states that the manufacture of raisin wine has never been successful in this country. This is, however, somewhat in contradiction with the fact admitted by them, that such wine is made on a very large scale by the makers of "sweets." British wines, so-called, are made by special traders; their produce is not subject to any excise impost, except as to the distilled spirits which they use for fortifying it. British wines, containing as they do a very large amount of sugar, mostly of the cheapest kind, are classed by the alcoholic excise with sweets, and hence their immunity from taxation. But we are not aware that British wine-makers are makers of any other truly so-called sweets beyond these wines, which we discuss shortly in the following.

We describe the production of raisin wine after Booth. Having made choice of good and well-preserved raisins (for in this case, as in every other fermenting process, everything depends in the first instance upon the quality of the first materials), they are to be carefully separated from their stalks, and minced into small pieces; these are put into a tun, or tub, according to their quantity, and covered with soft water at 150 to 160° Fahrenheit of heat, and well stirred. The fruit swells and imbibes the water. In this mixture is put a quantity of cream of tartar, previously dissolved

in a portion of water, equal to the two-hundredth part of the weight of the picked raisins employed. When the whole has cooled down to 60 or 70 degrees, the raisins are taken out by means of a sieve, and broken, bruised, and pressed more completely, when they are returned again into the liquid, and left to ferment. When the fermentation is nearly complete, as indicated by the falling of the head, the wine is put in casks to complete its fermentation; and, this over, is bunged and allowed to clarify in the usual way. From five to seven pounds of picked Malaga raisins to the gallon of water ought to make a good ordinary wine. Eight or ten pounds to the gallon would probably make a sweet wine, which would require a lengthened fermentation in the cask. It is to such wine that spirit is added to stop the fermentation and clear the liquid. But this spoils the product for at least a long time, and as a dietetic drink for ever. Raisin wine requires to mature for a year in cask before it is fit for drinking. It has generally a natural flavour, which causes it to be an agreeable beverage. But, as met with in trade, it is too often spoiled by being flavoured with elder flower, to imitate the muscat or muscadine perfume.

In the present day very large quantities of raisin wine are made in France from raisins imported, particularly from Smyrna.

Currant Wine: Red, and White, and Black.—Currants are eminently qualified to produce a good wine, provided that the must is corrected by the addition of water until its acidity is reduced to about 5 per mille, and by the addition of sugar its dissolved solids are raised to about 20 per cent. Booth maintains that currants are benefited by coction, but admits that the flavour of the wine may be thereby diminished. Black currants lose greatly in flavour by any degree of coction, and a syrup made from their juice, which is sold by a celebrated fruit-syrup maker, and is quite genuine, tastes only of the acid of the black currant, and has no flavour whatever left, so that no one could by mere tasting diagnose the origin of the syrup.

It is therefore probable that the good effect of coction upon currants, in some respects, may be counterbalanced by a loss in other respects. The good effect could probably be secured without drawback by coction in hermetically-closed vessels. We have made excellent currant wine from all three varieties of currants; the wine, in every case, was free from fault, full of taste and alcoholicity, of great characteristic flavour, and in the case of black currants of immense flavour and deep red colour. The ripest and best fruit should be chosen, cleaned, and crushed. To it should be added a quantity of warm sugar water, containing twenty pounds of white cane-sugar, in one hundred parts of solution, to be made therefore by dissolving one part by weight of sugar in four parts by weight of water. Booth gives a description of a laborious method of making currant wine, which in this country would yield a very acid product. He says that it was probably for the purpose of guarding against this *slightly acidulous* flavour that all the receipts for making currant wine, which have found their way into cookery books, or among the receipts of private families, recommend to mix a large proportion of water with the juice, making up the deficiency of strength with sugar, or, more directly, with spirit. He terms this a heterogeneous mixture, which usually required the yeast of beer before it will ferment, and judges that this produced a species of shrub, rather than wine, to which it bore scarcely any resemblance. This account shows that it is written without any experience on the subject, and that the records of ages reveal a correct practice. The adjustment of acid and sugar-water to the proportions above given imitates those of the best wine-must, and the mixture, containing the crushed fruit, ferments readily without added yeast, and completely, and furnishes a product which is in every respect *a wine*, and bears the unmistakable flavour and colour of the fruit from which it is made.

Gooseberry Wine.—The constituents of gooseberries in the ripe and unripe state are stated in Muspratt's Chem. Dict., 1st edition, "Domestic Wines," to be as follows :—

	Unripe.	Ripe.
Green colouring matter (chlorophyll)	0·03	..
Sugar	0·52	6·24
Gum	1·36	0·78
Albumen	1·07	0·87
Malic acid	1·80	2·41
Citric acid	0·12	0·30
Lime	0·24	0·29
Lignin or cellulose, with seeds	8·45	8·01
Water	86·41	81·10
	100·00	100·00

It will be seen from this that during the process of ripening the percentage of the acids does not only not diminish, as is frequently supposed, but increases considerably. The main accession, however, is that of sugar, which rises to a little above 6 per cent. Now if a wine were made from such ripe fruit, it would contain only about 3 per cent. of alcohol, and 2½ per cent. of acid; and although a fluid with so little spirit might with due care be preserved in a sound state, yet it would be far too acid to be agreeable for drinking. For it is a well-established rule of taste that any fermented liquid of the wine class should not contain more than a half per cent. of free acid. One hundred parts of ripe gooseberries therefore, such as were analysed in the above-given experiment, contain sufficient free acid to impart the proper acidity to 500 parts of liquid; 100 parts of such gooseberries therefore would have to be diluted with 400 parts of water to produce a liquid of the proper acidity. On the other hand, 100 parts of unripe gooseberries, with 1·9 per cent. free acid, would require less than 300 parts of water to produce a liquid of the proper acidity. To each 80 parts of the latter liquid 20 parts of sugar would have to be added, while to each 80 parts of the diluted liquid made with ripe gooseberries only between 18 and 19 parts of sugar would have to be added to produce a must fit for correct vinous fermentation. The excellent quality which gooseberry wine not rarely attains has given rise to the fable that it served for the manufacture of *British Champagne*, an imitation which was

often substituted fraudulently for the original. This is no doubt the largest of the gooseberries which do service as the subjects of little paragraphs at that time of the year when the people cannot be incited to peruse current literature even by sensational news. Truth is, that the wine from gooseberries becomes more easily effervescent in bottle than other wine, but it is untrue that it could be substituted for champagne, for its flavour is so unmistakable of the gooseberry, that any person of taste and experience would at once recognise it. The gooseberry succeeds well in northern latitudes, and those grown in Dundee, Aberdeen, and Inverness, are said to be superior even to those grown at Edinburgh. It is said that the gooseberry, particularly the yellow variety, which on account of its juicy quality is chiefly employed in making wine, has a period of maturity beyond which the juice loses its flavour and becomes insipid. It is further assumed that on this account so many English recipes for gooseberry wine recommend making use of the gooseberries before they are ripe, and make up for the want of their natural sweetness by an increased proportion of sugar. We agree with Booth that every unripe as well as overripe berry should be picked out of the fruit from which it is intended to make wine. We then adjust acidity and strength by the addition of water to the crushed gooseberries, and of so much sugar that the solids in the filtered juice amount to at least 20 per cent., and ferment the entire mash, without straining the juice from the husks. Immediately after the fermentation is over the wine is strained, and the murk pressed in a flannel bag or horse-hair cloth, such as is used for pressing apple murk. When the wine has become clear in cask, it may be put in Champagne bottles, and treated as is usual when it is intended to make effervescent wine. If the gooseberry wine was clear it will make so slight a deposit of secondary yeast that no disgorgement is required. Gooseberry wine as met with in English country places is too frequently acid, syrupy, or highly brandied; that is to say, the good old prescriptions, such as I have

seen them in cookery books two or three centuries old, have been discarded for newer recipes intended to produce imitations of the sweet and brandied sherries which were so common in the early part of this century. It is the deplorable effect of this change which has brought gooseberry wine into discredit and into disuse.

Elderberry Wine.—This wine is remarkable by its colour, flavour and mild taste. The berry contains so little acidity that to make the wine agreeable some tartar has to be added to it. Booth prescribes to submit the berries to a preliminary coction, by heating them to at least 170° F. It seems that this is intended to make the juice more concentrated. After the preliminary repeated heating and cooling, the juice is to be expressed ; to each gallon three pounds of sugar are to be added, and the solution is to be allowed to ferment in a covered vessel. The wine which will result from this operation is distinguished by no quality attractive to the taste, but may be mixed with every sort of grape wine, to which it will give body, an agreeable perfume, and a brilliant red colour. It is owing to this quality of the elderberry that it has been used for making a liqueur which in France was used to make or improve red wines, or rose-coloured wines, namely, the so-called Vin de Fîmes, made in the town of that name. There has been much idle talk about the colour of port wine being derived from elderberry, but we know from personal inspection that the grapes of the Alto-Douro are dark enough to furnish the deepest coloured wine, and that in the same district there are no elder bushes to be met with.

Elderflower Wine.—Raisin wine is flavoured with tincture of elder flower. While, therefore, the elderberry wine is deeply-coloured red, elderflower wine derives no colour from its flavouring ingredient. The elder wine of the British wine makers has a fundamental fault, namely, that it is too strongly flavoured with the elder flower. They should take an example from the makers of sparkling Moselle, and put elderflower tincture rather sparingly into their raisin wine.

Brambleberry, Raspberry, and Strawberry Wine.—Wines can be made from these varieties of fruit, but they have only the value of curiosities. Brambleberry wine has no attractive flavour at any time. The fine flavour of the raspberry evaporates almost entirely during fermentation, and the resulting wine is a liquid without any specific aroma. Strawberries behave similarly, and their aroma, in a fermented liquid, may make room to a heavy, repulsive odour. Both raspberries and strawberries are, moreover, too valuable as fruit for eating and for jams to become popular for any other use.

Wines from Cherries, Prunes and other Stone Fruit.—From stone fruit wine may be made by a process similar to those described in the foregoing. Much cherry wine is actually made by British wine makers, but is too often denaturalised by excess of sugar and addition of spirit. The fruit is rubbed in a wicker basket, until pulp and juice have passed into the tun below; the liberated stones are cracked and thrown into the pulp, to impart their peculiar bitter almond flavour to the liquid to be prepared. Although cherries give juice of a higher quality than most other varieties of fruit, they still require an addition of saccharine matter if wine be intended to be produced; in that case also it is desirable to add to must of very ripe cherries a proportion of cream of tartar. Morella cherries are usually preferred, but the black cherries of the variety called in France "la guigne," in Scotland "geen," are also used. In the Vosges, the Black Forest, and in Dalmatia, the marasche cherry is used to make a fermented liquid, which is, however, not used as wine, but distilled immediately after fermentation, and produces the excellent spirit called "Kirschenwasser," or maraschino. Prunes are said to be improved by coction, previous to fermentation, but we doubt whether the application of heat, originally undertaken to increase the percentage of sugar, may not disperse much of the aroma.

Orange Wine.—We have known good orange wine to be preferred by ladies at a dinner-table bearing a selection

of expensive grape wines. It had been made from 100 sweet oranges, 20 lemons, 32 lbs. of loaf suger, 5½ imperial gallons of water, 2 bottles of white wine, and half a pint of good yeast. The water and 28 lbs. of the sugar should always be boiled, and the expressed juice of the oranges and lemons be added while the mixture is hot; the yeast is added when the mixture has cooled to about 70° F. The skins of the oranges and lemons are well rubbed with the four remaining pounds of sugar, so as to form an oleo-saccharum, and this is added to the fermenting mixture forty-eight hours after it has begun to work. When fermentation ceases, the wine is racked into a new cask, the two bottles of grape wine are added, and the product is allowed to clarify.

Cowslip Wine.—The blossoms of the common cowslip, or paigle, communicate to neutral home-made vinous liquids a bouquet reminding of that of muscatel or elderflower. For the rest, these blossoms possess no ingredients which would make their employment advantageous to vinification. The basis of a cowslip wine of which considerable quantities are produced at Leicester, are sugar and lemon-juice; and the product is made slightly effervescent, so as to be an agreeable, and, as we are informed, only slightly alcoholic drink.

Wine from Mixed Fruit.—It is stated by Booth that there are many gentlemen who prefer wines made from mixed fruit to those of the simple kind; the mixture may be made up of some or all of the fruit that ripen at the same season, and in variable proportion. It is probable that such wine is made on account of its economic advantage. A useful recipe for making a wine of this kind is communicated in the eleventh volume of the 'Correspondence of the Bath and West of England Agricultural Society,' by a correspondent of the name of Matthews.

Ginger Wine and Ginger Beer.—These products are made of the same ingredients, but differ in this, that the former is more completely fermented for the purpose of preservation, whereas the latter is made for immediate use,

and bottled in such a state as to acquire in the course of a few days such a degree of fermentation as will make it very frothy when it is poured out. Moreover, ginger wine is generally much more alcoholic than ginger-beer. And it is one of the great advantages of genuine and well-made ginger-beer, that by its spice and effervescence it is highly refreshing, while by its low alcoholicity it is an agreeable stimulant without being intoxicating. With such ginger-beer should not be confounded the aërated drink called gingerade, which differs from ginger-beer in this, that, not being fermented, it contains no alcohol. A strong ginger-beer is made by boiling with every gallon of water 2 lbs. of loaf sugar and 1 ounce of bruised ginger, 1 ounce of cream of tartar, and one small lemon, sliced. To the cooled mixture some yeast is added, and the whole is set aside for fermentation. When the tumultuous fermentation is over, the liquid is bottled. Ginger-beer thus made is, when properly fermented, of considerable alcoholic strength, equal at least to strongest Scotch ale. A ginger-beer for ordinary use in hot weather should be much weaker; and for this purpose the initial mixture should contain only such a quantity of sugar as can be fermented in the bottle without any previous fermentation in the wood. This amount of sugar is about 2 to 3 per cent. of the mixture; when properly fermented this will give about 1 per cent. of alcohol, and a free effervescence of carbonic acid, and will therefore yield a beverage which can be used by young and old of both sexes, even in hot weather, without hesitation.

Mead, or Wine from Honey.—The English name mead is derived from the Saxon medo or medu, and is therefore identical with the Greek name methu, signifying originally, probably, a strong vinous liquor; but used by Homer exclusively for wine. When wine and beer, and in later centuries, distilled spirits, had to be sweetened, this was effected with honey, and then the word meth came to be applied to all drinks into the preparation of which honey entered as a factor. The Welsh signified by

metheglin, a liquor compounded of honey and wine, the same which the Germans called weinmeth; biermeth was made of beer and honey; essigmeth (oxymel) of vinegar and honey; wassermeth (hydromel), or simply meth, of pure water and honey, so that meth shared the fate of "lucus," in this, that as the latter was called so "a non lucendo," the former lost its meaning of strong intoxicating liquid, and acquired that of sweet non-alcoholic drink. At one time the word may have been used ambiguously, but this abuse was abandoned when, in consequence of the expansion of the art of brewing beer from barley, men learned the art of fermenting honey-water by means of the yeast obtained in the fermentation of beer. After that, meth or mead was almost exclusively employed to signify an alcoholic drink made from honey and water by fermentation. In King Alfred's translation of 'Orosius,' recording the travels of Ohter and Wolfstan, the latter is made to speak thus of the Eastern Country, which is supposed to mean the shores of the Baltic, and the banks of the Vistula. "This Eastern Country was very large, and contained many cities, each of which had its king. Great plenty of honey and fish were there. The king and the richest men drank mare's milk; but the poor and the servants drank mead. There was much wine; but there was no ale brewed among the Eastern people, for they had mead in abundance."

These people, therefore, probably imported their wine, no doubt by sea, from France, Spain, and the Levant. In England, honey-water was seldom fermented without yeast, because, as it was boiled and scummed, the yeast-germs naturally contained in it were destroyed, and could be renewed but slowly from the air, or suddenly by addition of yeast from beer. When honey is simply dissolved in water, of a heat between 80° and 90° Fahrenheit, it mostly enters into fermentation in ten or twelve hours. Into the mixture of honey-water intended to be made into mead, cream of tartar is mostly given; the French also add elder-flowers; but this seems to complicate the

fine flavour of the honey. Most prescriptions for the making of mead which we have perused indicate so much honey that, after the most complete fermentation possible, a strongly sweet thick liquid must remain. Macquer's prescription leads to a honey syrup so concentrated that it will support a fresh egg on its surface without allowing it to sink to more than half its bulk. Another French recipe prescribed to infuse six gallons of boiling water on eight or ten ounces of elder-flowers; to the infusion 2 lbs. of cream of tartar are to be given; afterwards 40 lbs. of purified honey are to be dissolved in it, and the wort thus obtained is to be started with 4 lbs. or 5 lbs. of good fresh yeast. Even where less honey is recommended, the mead obtained is to be strongly sweetened with cane sugar. We have no doubt that, independently of the fact that honey is a relatively dear material for the production of an alcoholic beverage, mead has become disused on account of the excessive sweetness which used to be imparted to it. Mead to be an agreeable beverage should not contain more than 25 lbs. of honey in 100 lbs. of the wort to be fermented; the presence of excess of cream of tartar is of less consequence, except as waste, inasmuch as it does not remain in solution in the wine; 1 lb. of cream of tartar upon 25 lbs. of honey would be sufficient.

Wine from Malt.—The extract of malt, termed wort, has an agreeable sweet taste, with only little of the peculiar barley flavour. A wort still more resembling a pure sugar solution can be produced by transforming a solution of pure starch into the peculiar barley, or malt sugar, which has received the name of maltose. Both common wort and this solution of maltose are easily fermented, either by evolution of yeast from aerial germs, or by the addition of yeast in quantity, as in the manufacture of beer. Maltose has an exquisitely sweet taste; it has the same composition as cane-sugar; but unlike this latter, is fermentescible by yeast directly, while cane-sugar is not so fermentescible, but requires the prolonged influence of much yeast, aided by acid, in order

to become interverted, as it is called, *i.e.* to be split up into the two fermentescible sugars termed dextrose and levulose. Maltose worts may be acidified with citric acid to the extent of ½ per cent., or with cream of tartar to the extent of 1 per cent. The wine obtained is so pure in flavour that any desired artificial bouquet may be easily imparted to it.

Booth describes a species of liqueur wine made from malt, which was sometimes to be seen at the tables of the Scotch ale-brewers. A pale wort of a very high gravity was attenuated by fermentation to half its specific gravity; at this period it was cleansed, and a gallon of good French brandy was added to every ten gallons of the fermented liquor. The spirits became perfectly incorporated with the wine within a year. It was usually drunk without any further addition or flavourings. We abstain from giving the complicated prescription for malt-wine published at the beginning of the present century by Dr. A. Hunter, of York. As it requires, while fermenting, to be daily roused with a stick during a month, we fear that few, if any, are likely to make up the prescription.

Birch and Plane Wine.—The sap of the birch (*Betula alba*), and of the plane-tree (*Acer pseudo-platanus*), have frequently served for the production of wine in this country, and do serve for that purpose abroad. Lightfoot, in his 'Flora Scotica,' gives detailed instructions for the production of birch-wine.

In the beginning of March, while the sap is rising, and before the leaves shoot out, bore holes in the bodies of the larger trees, and put tubes therein, made of eldersticks, with the pith taken out; and then put any vessels under to receive the liquor. If the tree be large, you may tap it in four or five places at a time, without hurting it; and thus from several trees you may gain several gallons of juice in a day. To every gallon of liquor 4 lbs. of sugar are to be added, and the mixture is to be allowed to ferment. Lightfoot advises to boil the liquor before and after the addition of the sugar, and to skim off all froth. This seems unneces-

sary, and is perhaps intended only to retain more sugar in the wine than would remain without the boiling. The resultant wine is agreeable.

The manufacture of the juice of the plane-tree is conducted in the same way, and the wine is said to be equally good. The American maple (*Acer saccharinum*), is a tree of the same genus. It is tapped in a similar manner as the birch, and the juice is so rich in sugar that none need be added to it if it is intended to ferment it; it even serves to produce crystallised sugar like that from the cane.

Sugar-cane, Beet-root, and Parsnip Wine.—Liquids prepared by fermentation from these plants have a coarse taste, and are, if drinkable at all, not attractive.

Beer.

Beer is an alcoholic beverage made from sprouted barley or malt, hops, yeast, and water. In the manufacture of some varieties of beer, sugar from various sources is also used; such sugar may be cane-sugar or starch-sugar, the latter produced either by the influence of acid (invert sugar), or of ferment (diastase maltose). In the manufacture of other varieties of beer, grains other than barley (*e.g.* wheat), are used; but in Europe this is rarely the case.

The quantity of beer produced in Europe has greatly increased during the last thirty years, owing not only to the increase in the well-being of the population, but also to the diminution or want of increase in the production of wine. The quantities of beer produced in 1873 in several European countries were: Great Britain, 50 millions hectolitres; Germany, 38½ millions; Austria, 12½ millions; Belgium, 9⅓ millions; France, 7 millions; Netherlands, 1⅓ millions; Russia, 1¼ millions. It will be observed that the production of wine in France, together with that of beer, amounts about to the same number of hectolitres as the production of beer in Great Britain.

The consumption of beer per head of population per

year, has been stated to be about as follows: Russia, 13 litres; France, 19·5 litres; North America, 26 litres; Austria-Hungary, 34·5 litres; Prussia, 39·5 litres; Baden, 56 litres; Saxony, 60·5 litres; Würtemburg, 154 litres; England, 200 litres; Bavaria, 219 litres.

Beer, under the name of wine made from grain, *e.g.* barley-wine, has been known to many nations since the earliest times. But it was probably then not made with hops, the use of which has become general only since the Middle Ages. Tacitus (Germ. c. 23), describes the barley-drink of the Germans as similar to spoiled wine. Diodorus (1, 14, 15, 34), has a better opinion of barley-drink, and does not think it much inferior to wine in flavour. According to this author, mankind received the barley-drink zythus, as well as the vine, from Osiris; and zythus, he adds, is a substitute for wine to those who cannot afford to buy wine. The Emperor Julian, however, did not think highly of the barley-drink of either Germany or Gaul, for in an epigram he describes it as smelling, not of the god Dionysos, but of the he-goat, which used to be sacrificed to that god. Beer is, nowadays, characterised and receives its full value by hops (cf. G. Thudichum, 'Traube and Wein in der Kulturgeschichte,' 1881). To which event in the history of beer the legend of Gambrinus, King of the Netherlands, owes its origin is difficult to ascertain (cf. Gruner, 'De confectione zythus sive cerevisiæ veteris, Jenæ 1805; also Journ. compl. des Sc. méd. 13, 253). The beers of various nations pass under the name of chica, saki, uytzet (Genth.); the later Latins termed it cerevisia, from the goddess Ceres, whence the early French cervoise. According to Merat and Delens (Dict., art. Aile), the English ale, or hel, was a beer made without hops; but the word has become synonymous with beer. Some kinds of beer are flavoured with bitter and aromatic substances other than hops; but they have no very wide area of consumption; thus the so-called spruce-beer is made with the branches of the spruce-fir (*Pinus sylvestris*, L.). The Canadian pine-beer made by the early French settlers was

called sapinette (from *sapin*, pine, being here *Abies alba*, *rubra*, and *nigra*, L.). Cook caused such spruce-beer to be prepared with a pine of New Zealand, and gave it to his sailors. Posset seems to have signified both whey and a mixture of whey and ale without hops; also, perhaps, mixtures of curd and whey, or sour milk with ale, which were eaten cold in summer, and mixtures of sweet milk with ale, eggs, spices, &c., which were drunk hot in cold weather.

Barley.—Several species of this cereal are cultivated in two principal forms, as winter and summer barley; it ripens up to 71° north latitude, and on mountains up to 1200 m. high; the winter crop requires from 270 to 300 days for vegetation, the summer crop 100 days. The latter is most suitable for beer. The chemical analysis of barley corn has yielded mean: water, 13·78; nitrogenous matter, 11·16; fat, 2·12; sugar, 1·56; dextrine, 1·70; starch, 62·25; cellulose, 4·80; ash, 2·63. Barley is transformed into *malt* by the process of germination. It is first steeped or soaked in water; the saturation takes place in warm water, or in summer time, in from 1½ to 2 days; in cold water, and during winter time, in from 5 to 6 days; during this process the barley increases in weight by from 30 to 60 per cent., and in volume about 25 per cent.; about 1 per cent. of the constituents of the barley pass into the soaking water and are lost. The swelled barley is allowed to germinate at a low temperature, while lying in heaps; the germination shows itself by the appearance, first of the rootlet (radicula); secondly, of the leaflet or feather (plumula), the beginning of the stalk and leaves, or haulm. This process requires from six to twelve days, and is completed, as regards the preparation of malt, when the leaflet has attained the length of about three-quarters of the length of the grain. The changes which occur in the barley during this process are, in the first place, a considerable increase of the soluble nitrogenous matters; the additions are ferments, of which diastase is the most important one, as by its power starch is transformed into

sugar in the most convenient manner; other ferments are peptonising like the gastric juice; but, like the asparagin formed at the same time, they are of less importance for the production of beer. Of the starch contained in the barley, a quantity is used up for the production of power, including heat; another portion of starch is transformed into dextrine; while a third portion is metamorphosed into maltose (the sugar peculiar to malt, and producible from any cereal starch by the diastase, particularly of malt). Altogether, the losses which barley experiences during its transformation into malt amount to about 14·7 per cent. of its weight; of these, 1·0 per cent. goes in solution in the soaking water; 10·2 per cent. pass away as gaseous products of the germinating process, or become dextrine and sugar, while 3·5 per cent. are made up by the radicles. In the ordinary process for making beer, the malt is not used in its fresh or green state; but is dried, and the shrivelled rootlets are removed mechanically. These latter are used as food for cattle.

The malt is roughly ground and mixed with warm water, so that the heat of the mixture, termed mash, is from 60° to 65° C. The liquid part, termed wort, is boiled or otherwise treated until it has the desired degree of concentration. Every per cent. of sugar yields about a half per cent. of alcohol by fermentation; a wort, therefore, which is intended to yield beer with 4 per cent. of alcohol and 5 per cent. of extractives, must contain $2 \times 4 + 5 = 13$ per cent. of solids in solution.

During the process of mashing the starch in the malt is almost entirely transformed into the peculiar sugar termed maltose, or barley sugar; this body, long mistaken for dextrose or grape sugar, was shown by Dubrunfaut to be peculiar, to rotate the ray of polarised light three times as much as dextrose, and on the other hand to decompose only about two-thirds of the amount of alkaline copper solution which is reduced by dextrose. The chemical formula of malt sugar is probably like that of cane sugar $C_{12} H_{22} O_{11}$.

Diastase is contained in malt in quantities varying between

0·1 and 0·2 per cent. Its power over starch is destroyed when it is exposed to a temperature above 75° C. The dextrine formed by the side of maltose is a kind of soluble starch, which derives its name from its dextro-rotatory influence upon polarised light, and is not capable of being fermented by yeast; and by long-continued influence of diastase it can pass into maltose. In the manufacture of beer it remains in the beer, because the action of diastase is cut short by the boiling of the wort with the hops; but in the manufacture of spirit the diastase is allowed to continue its action during the alcoholic fermentation, so that most dextrine is transformed into sugar and alcohol.

When the action of the diastase in the mash is completed, the wort is separated from the exhausted malt by filtration. The malt may again be treated with water, and the product added to the first wort, or it may be kept and treated separately for the production of small beer. The clear wort is now boiled with hops.

Hops are female non-impregnated compound flowers (catkins) of the hop plant (*Humulus lupulus*, L.), which belongs to the family of Urticaceæ. The hop plant is probably indigenous to many parts of Europe and Asia. In early days of beer production wild hops only were used, as is the practice in Styria at the present day; but it has been largely cultivated during nearly a thousand years, and at the present time the hops of Bohemia, Bavaria, Baden, Würtemburg, Alsatia, England (Kent and Surrey), and America are staple articles of a large trade. In Europe 53,000,000 kilogrammes of hops are produced annually on an average; in good years the production may rise to near 80,000,000 kilogrammes. The active ingredients of hops are the mixture of substances termed lupulin, which is deposited in minute yellow adhesive globules underneath the bracts of the flower tops, and amounts to from 20 per cent. to 30 per cent. of the dry hops. This lupulin contains hop resin (50 per cent. to 80 per cent.) and hop bitters, or bitter acid of hops, which imparts to beer its bitter taste. It further contains hop oil, a mixture of volatile oils, boiling

between 140° and 300° C, and supposed to contain alcohols and hydro-carbons, which are not yet accurately known. This hop oil imparts to beer a peculiar aromatic flavour. Lupulin further contains tannic acid = 1·18 per cent. of the hops, wax, nitrogenised and saccharoid matters, which are of minor influence upon the composition of beer. Besides the 30 per cent. lupulin, hops contain about 15 per cent. of other nitrogenised matters, 16 per cent. of cellulose, 6 per cent. of ash, from 2 per cent. to 3 per cent. of sand, and the rest is made up by moisture. This refers to hops dried in the air, or in drying kilns at about 40°. To preserve hops from mould and other changes they are sulphured, *i.e.* impregnated with sulphurous acid gas.

The clear wort obtained, as above described, is boiled with hops in such quantity that for ordinary beer the wort from 100 parts of malt receives from 1½ to 2 parts of hops, while for lager beer and the stronger ales the wort receives from 2 to 3 parts. Of the ingredients of the hops about 30 per cent. pass into the wort, consisting of 10 to 14 per cent. hop-resin, 3 to 5 per cent. extractives free from nitrogen, 4 to 6 per cent. nitrogenised, and 3 to 5 per cent. mineral matters. The hopped wort is now filtered from the exhausted hops; it contains from 8 to 15 per cent. of matters in solution, of which sugar of malt (maltose) and dextrine are the largest in quantity; the proportions of these matters to each other vary greatly according to the intentions of the brewer, or according to the greater or lesser success of the mashing operations; it has been found that the relation of maltose to dextrine may vary between 1 : 0·43 and 1 : 7·17. The filtered hopped wort is cooled as quickly as possible, in case it is intended for upward or high fermentation to from 12° to 18° C., in case it is intended for downward or low fermentation to from 3° to 8°.

The wort thus cooled is placed in the fermentation vats, and to every 100 litres of from 10 to 15 per cent. strength 0·5 to 0·6 litres of good thick beer yeast are added. The high fermentation is completed in from four to eight days, the low fermentation lasts much longer. While the

fermentation proceeds the rise of temperature is counteracted by floating coolers filled with ice. The process of fermentation splits maltose first into dextrose sugar, and this latter into alcohol and carbonic acid. A part of the dissolved nitrogenised matter is precipitated, and a quantity of new yeast is formed, while the old yeast dies off. The fermentation process further produces glycerine, succinic acid, small quantities of acetic and lactic acid, and some ethers. Before the fermentation is complete, the beer is transferred into barrels, and clarified by various means; one of the most common processes is to maintain a weak secondary fermentation in the barrels, and allow the froth to escape from the bung-hole; this secondary fermentation is aided by placing wood shavings into the barrels, and adding small quantities of strongly fermenting wort from time to time.

Beer becomes stronger or weaker according to whether more or less malt or other saccharine matter is used in its production. Beer which is to be transported from the place of its production to long distances, or to be exported to other countries by land or sea, must contain more alcohol and extractives than beer to be consumed in the locality of its manufacture. The colour of beer is mainly produced by extractives formed in the malt; of these less is found in malt dried at 30° to 40°, more in malt dried at higher temperatures. Very dark beer, *e.g.* porter, is made with a portion of roasted malt, or with burnt sugar. Most varieties, even of the best beer, are partly coloured and flavoured by special preparations, which increase its attractive aspect and flavour or bouquet.

It is supposed that hops are sometimes supplanted, entirely or in part, in the manufacture of beer, by absynth (herb), menyanthes (leaves), quassia (wood), gentian (root), and some others. But these adulterations are rare, and if practised persistently would no doubt be discovered, and the liquids produced by their aid would be declined by the public.

Much more than by intentional adulteration is beer

endangered by the development of unwelcome ferments, which multiply by the side of yeast. Most troublesome in this respect is the lactic acid ferment, which may appear already in the mash ; it becomes dangerous in wort before vinous fermentation if the former is not cooled down quick or low enough, and the yeast added is impure, or not sufficiently active, so as to crowd out by a rapid development of the yeast fungus other organised ferments. Beer then becomes sour, and of bad taste ; it is turbid by suspended ferment and precipitated matter. The less dangerous ferment is the acetous, which requires the presence of alcohol for its development, while the lactic ferment acts not upon alcohol, but upon sugar and dextrine. Other ferments are those which produce viscosity and scud and decoloration of the beer. These ferments and the means of avoiding their evil effects have been described by M. Pasteur. He has more particularly shown how to produce pure yeast.

Yeast is the uniform mass of microscopic fungi (*Saccharomyces cerevisiæ*), which have the power to transform sugar into alcohol and carbonic acid. Compressed yeast contains from 75 to 83 per cent. of water. Low fermentation yeast, considered as free from water, contains albumen 36 per cent., gluten-casein 9 per cent., pepton 2 per cent., fat 5 per cent., extractives 4 per cent., cellulose 37 per cent., and mineral ingredients 7 per cent. The fermentation is part of the growing and life action of the yeast ; in the beginning it requires a little oxygen, but its main action takes place without any participation of the oxygen of the air, and is not interrupted by a pressure rising to 17 atmospheres. One hundred parts of extract of malt, considered as dry, will yield by fermentation 48·4 alcohol and glycerine, &c., 46·3 carbonic acid, and 5·3 yeast.

The water to be used in brewing should be pure, clear, and not too hard ; it should not contain much organic matter, as this has a tendency to aid the development of mildew on the steeped barley, and of lactic acid ferment in the mash. A very hard water diminishes the production of maltose ; a water containing gypsum aids the wort in

becoming clear. The presence of some chloride of sodium, or common salt, is not hurtful, but may not exceed a certain limit, which is fixed by certain restrictions concerning beer which are enforced by authority.

Beer is stimulating and intoxicating by means of its alcohol; it is refreshing by its carbonic acid; it has a peculiar sedative influence upon the nerves by means of its lupulin—this effect is very like that of opium; the hop oil gives it its aroma. The extractives make it somewhat nutritive, and give it a roundness of taste termed body. The taste is vinous, sweetish, and bitter at the same time. The alcohol varies between 3 and 5 per cent., the extractives between 5 and 8 per cent., sugar may approach 1 per cent., dextrine and gum vary between 2 and 5 per cent., carbonic acid and glycerine are mostly present in equal proportions, namely, 0·22 per cent., the lactic acid varies between 0·1 and 0·3 per cent., the ash between 0·2 and 0·27 per cent. When to any beer an excess of ammonia is added a precipitate of phosphate of magnesia and ammonia ensues. The specific gravity of beer varies between 1·0142 and 1·0237.

Distilled Spirits.

Distilled spirits receive various names, according to the materials from which they are derived. The reasons for which they are distilled are mainly that the liquors from which they are obtained are not drinkable, or not agreeable in their natural state. Spirits are also compendious essences, which can be easily transported and made into a beverage by mere mixing with water.

The number of establishments for the production of spirit in the world amounts probably to half a million. In the German Empire there are 40,000 distilleries, which produce more than 4,000,000 hectolitres of spirit of 80 per cent. of strength annually, and use in this production about 25,000,000 hectolitres of potatoes, 5,000,000 hectolitres of corn, and more than 1,000,000 hectolitres of beet-root

molasses. In France the distilleries of eau-de-vie produce annually 600,000 hectolitres from wine alone, of which 180,000 hectolitres are Cognac brandy so-called, made in the Charente, while the remainder, 420,000 hectolitres, are so-called trois-six, made in the South of France. Some brandy is produced from murk, and some from yeast. A number of spirits are produced from sweet fruit, cherries, plums, &c., and from syrup obtained from the beet-root or the sugar cane. The large bulk of spirit consumed by the labouring classes in the shape of whisky and gin is produced from barley, rye, rice, maize, and other materials containing starch, amongst them foremost the potato, which, as we have seen, furnishes in Germany the material for the production of at least four-fifths of all the spirits distilled there. In England and Belgium rye is mainly used for the production of whisky and gin, with some malt, to effect the conversion of the rye starch into fermentescible sugar. This conversion is effected by the mashing process described under beer.

In most cases the agent for the transformation of the starch into sugar is diastase, in some, however, sulphuric acid is used. Sugar so produced does, however, not give a spirit of good taste, though by rectification and charcoal pure alcohol can be produced from it. The potatoes are steamed and crushed previous to being mashed.

The fermented liquids are introduced into stills and the spirit is driven out by heat, and condensed in an apparatus called a cooler, or, from its common shape, a worm. In the still there remains a mixture of liquid and solid matter, termed "wash," which is used as food for animals, mainly cattle and pigs. Such wash from rye contains about 93·48 per cent. water, 1·4 per cent. nitrogenised substances, 0·22 per cent. fat, 4·05 non-nitrogenised matters, 0·52 cellulose, and 0·33 per cent. ash. The wash from potatoes contains more cellulose (cork), 0·92 per cent. (from the peels); less non-nitrogenised matter, 2·17 per cent., the other matters in quantities similar to those from rye wash. The wash from beet-molasses is remarkable in this, that it

contains 12·04 per cent. nitrogenised, and 4·56 per cent. non-nitrogenised matter, no fat, and 1·54 per cent. of ash.

The residues from distillation have mostly an awful smell, and even the residues from wines are by no means well flavoured ; indeed the latter, in France, have given rise to contentions as nuisances, when they were discharged into water-courses.

The distillates, on the other hand, contain besides the ethylic alcohol common to them all, other volatile matters, which differ according to the material, and impart to the distillate so peculiar a smell and taste that its origin can thereby be accurately recognised.

Spirit distilled from a grape-mash, or from wine, smells of wine or œnanthic ether, and is termed brandy ; spirit distilled from a malt or grain mash smells of grain, and is whisky ; spirit distilled from a sugar-cane mash, or from molasses, smells like dilute butylic ether, and is termed rum ; from potatoes, smelling of fusel, potato-spirit ; from cherries, smelling of bitter almonds, cherry water (Kirschenwasser), maraschino ; from rice, smelling like Russian leather, arrac ; from apple wine, smelling like quinces, the spirit is termed malac. In all cases the quality of the distillate is absolutely dependent upon the qualities of the materials which are used in the production of the mash. The mercantile value depends on the peculiar flavouring ingredients, and this is much higher than that of the mere ethylic alcohol.

Rectification consists in redistillation, with the addition of certain chemical solvents, chiefly of an alkaline nature, which serve to retain some or all the objectionable matters in the bottom of the still, and to prevent them from passing over with the new, or second, or rectified product.

There are varieties of brandy, whisky, or rum which may be improved by slight rectification without loss of their distinctive characters. Something disagreeable has been taken out of them, and they are still what they were

before, not of first-class quality, but better for the process to which they have been submitted, and still marketable. Again, there are certain varieties which are so nasty, or so deeply tainted from the faults of the raw material, that the taint can only be removed by a degree and amount of rectification which removes the distinctive characters also; and then we no longer have rectified brandy, whisky or rum, &c., but only rectified spirit, from which everything distinctive of brandy or whisky or rum has been removed. From potato spirit the fusel oil is removed by filtration through animal or vegetable charcoal. The coal acts most successfully, when the spirit is of proof strength; and the contact is continued for several days (Döbereiner). The first spirit which passes in the process of rectification contains matters of lower boiling point than alcohol, *e.g.* aldehyde; then passes the bulk of the alcohol, and afterwards matters which have a higher boiling point than alcohol, namely propyl-isobutyl and amyl-alcohol. Before the latter begins to pass over the distillation is mostly interrupted. The residues, containing the heavier alcohols and acids, if it is desired to obtain them, are distilled separately in particular stills. A mode in which an agreeable flavour can be imparted to silent spirit, which has stood over charcoal, is the following:—Certain proportionate quantities of acetic and sulphuric acid are added, and the mixture is again distilled. Small quantities of acetic and other ethers are formed, and the rectified product has the agreeable flavour of these new compounds.

When spirit is highly rectified it becomes gradually more concentrated, until nearly absolute alcohol, or spirit of from 90 to 95 per cent. strength is obtained. First distillates generally have the composition of brandy originally so-called, that is to say, they consist of a mixture of nearly equal parts by weight of alcohol and water.

A variety of spirits were examined, and found to have the following amounts of alcohol:—

	Alcohol Volume Per Cent.	Weight Per Cent.	
Russian Dobry Wutky	62·0	54·2	
Scotch whisky	50·3	42·8	H. Grouven.
Irish do.	49·9	42·3	"
English do.	49·4	41·9	"
Gin (Genever)	47·8	40·3	"
German schnaps, common	45·0	37·9	"
American whisky	60·0	52·2	"
Rum	49·7	42·2	"
"	51·4	43·7	Koenig.
Cognac	55·0	47·3	"
do.	69·5	61·7	"
Arrac	60·5	52·7	"

Wine Brandies of the South of France.—Large quantities of brandy, or eau-de-vie, are distilled from wine, and some from murk over which red wine has fermented, in the South of France, the ancient province of Languedoc, more particularly in the department of the Hérault, bordering upon the Mediterranean. The brandy is called of good taste (*de bon goût*), when the wine from which it has been made was sound. When the wine was spoiled in any way the resulting spirit is ranked with and termed spirit of murk, or of bad taste (*de mauvais goût*).

All these brandies pass in trade under names which are derived from their strength. We must premise a few observations on that subject. A certain quality is termed "Proof of Holland." This is given by Rendu ('Vins du Languedoc,' i. 71) as of 52 vol. per cent. strength; but Payen ('Chimie industrielle,' 3rd ed. p. 712) gives Proof of Holland at 58·7, and Proof of London at 58 vol. per cent. British (or Sikes's) proof spirit at 15°5 contains 57·06 vol. per cent., or 49·24 weight per cent. of absolute alcohol. The designations of spirits of various strengths used in the Languedoc and other parts of France are derived as follows:—Common eau-de-vie is accepted as the standard, and supposed to show an alcoholic strength of 19° of Cartier's instrument at 12°5 temperature. It then contains a little less than 50 vol. per cent. of absolute alcohol. Trois-six is a spirit, of which three volumes added to three

volumes of water were supposed to give six volumes of eau-de-vie of 19° Cartier. This trois-six is the common wine-alcohol of commerce, marks 33° on the scale of Cartier, and contains, consequently, 84·4 vol. per cent. of absolute alcohol. Trois-cinq is a spirit of which three volumes added to two volumes of water were supposed to give five volumes of eau-de-vie at 19° Cartier.; while trois-sept is a spirit of which three volumes added to four volumes of water were supposed to give seven volumes of standard eau-de-vie. It is evident that by the introduction of the accurate chemical methods of ascertaining the strength of spirits these names no longer cover accurate definitions. But whenever they are used in French works, or in the following without the definition of the exact strength in vol. per cent., or degrees Cartier, we may assume that by 3/7 is meant a spirit of 94 vol. per cent.; by 3/6 a spirit of about 84 vol. per cent.; by 3/5 a spirit of about 78 vol. per cent.; by "Proof of Holland" and "Proof of London," a spirit about equal to British proof according to Sikes's tables; by eau-de-vie double de Cognac, a spirit of 52·5 vol. per cent.; by eau-de-vie as commonly sold in retail, a spirit of 49·1 vol. per cent.; and by common feeble eau-de-vie, a spirit of 45·5 vol. per cent.

The trois-six of murk, or of bad taste, is from 25 to 50 per cent. less valuable than that of good taste. The latter is the most important product of the still both as regards quantity and quality. It is obtained by means of a still which, from its inventor, is called De Rosne's. As the wines of the plain, which are used for distillation, contain from 7 to 11 vol. per cent. of 3/6 of 84°, an apparatus which can produce four pièces per day, and consume 336 hectolitres of feeble wine of the plain, containing 7 per cent. of 3/6, will, when consuming wines containing more alcohol, consume a lesser quantity. The average strength of the wine distilled is 11 and 12 per cent. of three-six when the year is good, so that a manufactory which produces four pièces of three-six in twenty-four hours, will consume from 230 to 240 hectolitres per day. Such a manufactory

therefore discharges every day more than 200 hectolitres of residue or wash.

The strength of spirit in the Hérault is frequently ascertained with the aid of the alcoholometer of Bories. This is a very ancient instrument, and manufacturers and producers of the Languedoc are as reluctant to give it up as the Germans are with regard to that of Tralles, or the English with regard to that of Sikes, and the inhabitants of the Charente with regard to that of Tessa.

There are in the Hérault four markets for spirits distilled from wine and murk ; Béziers (on Fridays) ; Pézenas (on Saturdays) ; Cette (on Wednesdays) ; and Lunel (on Mondays). To one or other of these markets the producer or distiller generally takes his brandy, accompanied by a written warranty of its alcoholic strength. The inspector of the market tests the spirit himself, and if he finds the warranty correct, admits, if he finds it incorrect, returns the spirit. Each separate barrel, termed pièce, is thus tested. The limpidity of the spirit must be perfect ; it must be colourless and of good taste, free from strange or bad taste.

The 3/5 and 3/6, and Proof of Holland, are employed to strengthen wines—as the French say, *viner les vins*—which have not sufficient alcohol of their own (technically termed "body") and are intended to be exported. All varieties of distillates are used for making, by dilution with water, the better class of eau-de-vie of Montpelier, which is drunk as such, or diluted with water. The best qualities of spirit are made, as in the Charente, from white wines just fermented, made generally from the grape termed "good quality of Terret Bourret." Good qualities are also produced from wines from the Picpoule. New red wines, provided they have not been allowed to ferment with the stalks, also give eau-de-vie of great softness.

The average annual production of 3/6 in the four departments—the Eastern Pyrénées, the Hérault, the Gard, and the Aude—is estimated at 500,000 hectolitres. It is produced either by manufacturers who make a distinct

occupation of it, or by farmers who have a still attached to their farm arrangements. These farmer distillers are more numerous in the circle of Béziers than in that of Montpelier, but on the whole the larger quantity of the wine is distilled by the professional distillers. This is by no means to the advantage of the product, as the 3/6 distilled immediately after fermentation is (as in the case of Cognac) always the best.

The murk is distilled by persons who use the residue either as food for sheep or as manure ; 13,000 kilos. of murk yield about 600 litres of 3/6 of bad taste.

The distilled spirits of the South of France are either consumed in the country, or exported, and consumed by most nations of the earth as eau-de-vie or brandy, or in the shape of many liqueurs.

Brandies of the Department of the Charente and Cognac.—Near the little town of Ruffec, the hill country, as far as the eye can reach, is covered with vines, mainly white varieties, the folle blanche, boilot, blanc doux, colombas, sauvignon, and St. Pierre. Of these varieties the first-named one gives the sweetest and best-flavoured spirit, the characterising ingredient of the eau-de-vie Cognac. The wine of the folle blanche is not agreeable to drink, although it is rich in alcohol. Wine made from black grapes does not yield a spirit of the same soft and bouqueted properties as that obtained from white wine. The varieties of vines cultivated for red wine are named balsac, maroquin and dégoûtant. The latter is a peculiarly characterised plant ; it affects the shape of a tree, its leaves are felted, and its grapes black and shining like coal.

In the Charente the wines are distilled immediately after the fermentation is over. Distillation therefore is carried on during the whole winter. Almost every other vineyard proprietor possesses a still. Those, however, who do not possess a still, sell their products to the larger distillers, or get it distilled by the migrating distillers, who go about from village to village and distil the spirit out of the wine of any comer. By the time spring arrives the whole of the

wine is mostly distilled. The spirit obtained is for the most part colourless, and of the strength called "four degrees of Tessa," equal to from 59 to 60 volumes per cent. of absolute alcohol, or a trifle stronger than British proof spirit. Its strength is mostly ascertained by the alcoholometer of Tessa, a somewhat antiquated and irregular instrument, known and used only in the Cognac district. It is supposed that each of its degrees above four is equal to three volumes per cent. of alcohol, so that "five of Tessa" would be about 63 volumes per cent., and so on. Calculating the value of the lower degrees at that rate, the zero point of Tessa would be about 47 to 48 volumes per cent. of absolute alcohol. We may surmise it to coincide with the strength of eau-de-vie as formerly sold in commerce, namely 49·1 volumes per cent. New cognac, like new whisky, has a disagreeable, burning and rough taste, without any flavour, and is, in fact, undrinkable. It is kept in barriques of 200 litres for a period of from one to four years. During that time it ameliorates, becomes sweet and tasty, and extracts from the wood the light-brown, amber, or yellowish colour which it has when sold in trade. Very old and fine brandy develops a flavour reminding strongly of vanilla; it is, like rum, quite free from even the suspicion of fusel oil or amylic alcohol. The quantity of brandy produced in the Charente amounts to 180,000 hectolitres, being the produce of the distillation of 1,400,000 hectolitres of wine, which together with 300,000 hectolitres sold as wine and drunk in the country, make up the 1,700,000 hectolitres of wine which grow annually on the 112,648 hectares of vineyards in this department. It is estimated that one bottle of cognac brandy of a strength of several degrees over-proof is obtained from six to seven bottles of wine in good years. In bad years eight to ten bottles of wine are required to give a bottle of Cognac. The value of wine in this part of France is very small, no more than from 8 to 10 francs per 200 litres being paid for white, and 18 to 20 francs for red wine. Yet wine continues to be produced, no doubt because climate and soil do not

admit of any other crops. The little humus there is rests everywhere upon a limestone, which crops up so as to cover the land with fragments. The only cultivation which this soil receives is a hoeing in spring. The vines are cut in spring, and beyond these no further operations are undertaken either upon the soil or the vines; the rest is left to the sun.

Addition of Spirit to Wines.—To consumers of sherries, ports, Spanish red, South French, and a variety of other wines, the consideration of the origin of distilled spirit should be as interesting as that of the original wine itself. For sherries and ports and Catalans receive nearly half their alcohol in the shape of Berlin potato-spirit, while South French receives several per cent. in the shape of trois-six; and Champagnes, Burgundies, Clarets, and other wines of central France receive a portion of their alcohol in the shape of Cognac brandy. Of Cognac brandy, of course only the tasteless or slightly tasting sorts are used for mixing with the wines indicated.

When we say "Berlin potato-spirit" we do not mean thereby to do more than indicate the origin and place of manufacture or sale of the spirit in question. We do not intend to convey that this spirit is not on the whole very pure alcohol, or very pure silent spirit, so called, and mostly as free from fusel-oil as a spirit need be. Indeed it is, or can be made, so pure, that it bears being mixed with most other varieties of alcohol of pronounced flavour, without introducing into them any new or extraneous flavour. It is for this reason that it is preferred for mixing with wines containing much saccharine and extractive matter, like port and Spanish red.

On the other hand the pure alcohol from grain or potato cannot be drunk by itself, without having received some addition in the shape of flavouring matter. For this purpose it is, like whisky, placed into wine casks, particularly sherry casks, and allowed to extract the wine and flavour which has been sucked up by the wood. Or it is flavoured with certain kinds of ether artificially produced, particularly

œnanthic ether, which gives it some resemblance to Cognac brandy, and in that shape is sold as British brandy. The word "brandy" in England is mostly intended to signify "Cognac brandy;" whisky and gin, though actually being brandies, i.e., burnt or distilled waters, or spirits, not being called brandy.

Whisky.—Whisky is a spirit which is distilled either from fermented malt, or a fermented mixture of malt and unmalted corn, the corn being rye, barley or oats, in a so-called pot-still, which brings over together with the spirit a variety of flavouring and other ingredients from the grain. If the grain were damaged, mouldy, or ill-flavoured, the spirit thus made from it would be either undrinkable or inferior. Hence to obtain good whisky it is necessary to use only the very best malt and grain which can be obtained.

Silent spirit is made in what are called "patent" stills, from any vegetable matter which will yield alcohol by fermentation; and the patent still, when properly and carefully managed, brings over alcohol and water only, leaving all flavouring matter behind. Hence by its aid pure spirits can be obtained even from damaged materials, and the use of perfect materials confers no advantage on the product. But it is contended by the whisky distillers that such spirits are not by any means whisky, and, being destitute of flavouring ingredients, are undrinkable.

Whisky, therefore, has an original flavour, but contains further ingredients, *e.g.* volatile oils and vegetable acids, which by time, *i.e.* so-called maturation by keeping, are transformed into substances of more agreeable smell and taste, substances which, although they do not seem to have been isolated chemically, have, owing to the manner of their formation, been termed ethers. They are easily discoverable by their smell and taste, and it is also said, by their power to produce exhilaration, which is exercised over and above the similar effect of the alcohol which holds them in solution. The ethers are extremely volatile and unstable; they belong to what may be called the

fusel-oil family, and, in some varieties of spirit, fusel oil is among the substances in the form of which they first appear, and out of which they are formed by time.

The presence of grain ethers is the condition of the genuineness of whisky.

Silent spirit, on the other hand, undergoes no change by keeping, and must be flavoured to become drinkable. For that purpose it is either made smoky, to become like Scotch, or it is mixed with Irish pot-whisky, to become like Irish whisky. (Cf. 'Truths about Whisky,' London, 1878.)

The product of the patent still derives its name from the fact that it is mere alcohol and water, "having no distinctive qualities, telling no tales to nose or palate of the source from which it was obtained, and hence, in the almost poetic language of the trade, is commonly called silent spirit." ('Truths about Whisky,' p. 32.) The owner of a patent still, instead of being confined, like a whisky distiller, to the use of the best materials, is able to make his spirit from any, even spoiled and waste materials, and with little reference to any other quality than cheapness. The worst of the spirit thus produced is fit only for methylation, preparatory to being used for trade purposes exclusive of consumption as a beverage. When intended for a beverage it must be rectified and flavoured. It thus serves as a basis for the implanting of artificial flavours, which may be those of sham whisky, sham brandy, or sham rum.

Whisky is explained to be a corruption of the Irish and Erse word "usquebaugh," water of life, the French eau-de-vie.

Strength of Burnt Spirits.—The finest Dublin whisky, when made, is reduced to a uniform strength of 25 per cent. over proof, and is stored in casks of considerable size; its full maturity and excellence cannot be reckoned upon under an age of from three to five years. The grain constituents of perfectly new whisky are not palatable in the estimation of people in general; but after about a year the whisky may be said to be drinkable, after about two years

to be good, and after about three years to be as good as anything with which the average consumer is likely to become acquainted.

Arac (arak, arack, arrack) is the name of the spirit made from rice. The same name with a slight terminal variation is applied, as *araka*, to the alcoholic product of the distillation of koumiss, used by the Tartars; as *araki*, applied in Egypt to an alcoholic liquid prepared by fermenting dates; as *araki*, applied in various other parts of Africa to fermented palm-tree sap.

Liqueurs.—The first class of liquids of this kind have been called liqueur-wines, and are wines made from fruit without subjecting it to fermentation. Booth terms them appropriately preserves diluted with spirit. They form agreeable and nutritive stimulants, and are made and used by all nations. In the 13th and 14th centuries they were much used under the name of piments or pigments, from the spices with which, as well as honey and wine or brandy, they used to be prepared. A standard wine piment of the time of Richard II., bore the name of hippocras, another that of clarry. Of these so-called medicated liquors the only kinds still in use are wermuth or vermouth, which is manufactured in Hungary, Italy, and France, and much used in Mahommedan countries; "bishop" is prepared by extracting one or more toasted Seville oranges by a certain amount of Burgundy or other red wine, and sweetening the whole with sugar; when Rhine wine is used for this infusion, the product receives the name of cardinal, and when Tokay is employed it is termed pope. These mixtures are perhaps mainly made to improve wines which are not so pleasant when drunk in their unmixed state.

These fruit-juice liqueurs have the advantage that they can be made perfect in a few days: they can be made more or less alcoholic, in technical phrase "generous."

Cherry liqueur is one of the most fragrant drams of this class. It is particularly well made in Scandinavia, with the aid of the northern or Vistula cherry (Kärsebeer of the Danes). The cherries are bruised together with their stones, and

heated over a slow fire so that about a third of their weight is evaporated in the shape of water. To the pulp from twelve pounds of cherries, weighing after the concentration eight pounds, add four pounds of good red wine and two pounds of proof spirit or brandy. Leave the mixture in a closed vessel until clear, and then decant and bottle.

The concentration by heat may be avoided, if to every gallon of cherry-pulp four and a-half pounds of white sugar are added. To the mixture half its volume of spirit should be added.

In a similar manner liqueur wine may be made from white cherries, mixed fruit, and from apricots and peaches. They can be fined with isinglass or milk.

Liqueur wines made from grape-must without fermentation are produced in many parts of the south of Europe. The ripe grapes are generally dried to some extent in the sun, and then pressed. The specific gravity of such must may vary between 13° and 22° Baumé. It is immediately mixed with one-fifth of its volume of alcohol of 40° Cartier, and the mixture is put into the sun to amalgamate. The Spaniards call such liqueur "dulce," and value it according to its age. They drink a little glass of it the first thing early in the morning, and call the practice "tomar la mañana," taking the morning. The so-called muscat of Rivesalte, Frontignan and Lunel, in the department of the Hérault, are made in the same manner. Such wines have also been made with considerable success in Australia. Some of the wines of the Cyprus Commandery, and Cape Constantia, are also unfermented liqueur-wines—juice of the grape preserved by alcohol.

True liqueurs are solutions of sugar in alcohol to which a flavouring ingredient has been added, also colouring matter sometimes. A number of such liqueurs are known by all the world, and will probably survive many changes of things hereafter. Thus noyeau is a liqueur in which the crushed almonds of stone fruit have left their prussic acid flavour. Curaçao derives its flavour and colour from the Seville or bitter orange. Anisette is flavoured by aniseed, and is

much used in the south to flavour a drink of cold water in summer time. There is the absinthe liqueur, of which the erratic conduct of some French youths has been supposed to be a consequence. There are numbers of compound liqueurs of which the recipes and monopoly of manufacture are claimed by religious brother- and sister-hoods, *e.g.* Benedictine-bitter, Chartreuse, &c. There are liqueurs made with peppermint, others with carraway-seeds, which latter is particularly esteemed in the north of Germany. A most elegant liqueur is termed parfait d'amour, which unites in itself all the refinement of noyeau and maraschino de Zara. These aromatic liqueurs are by the French termed ratafias, and are in France taken after dinner in small quantities. This word is supposed by some to be derived from the Malay tâfia, signifying a distilled spirit prepared from sugar-cane; in Italian the form taffia for ratafia is not unfrequently employed. According to others the word is derived from the latin formula "res rata fiat," *i.e.* the matter approved or resolved shall be done, and the liqueur drunk on such an occasion received the title derived from the final formula. In other countries, however, the taking of liqueurs of a very compound nature, at frequent intervals independently of meals, has become habitual, and in the United States of America, *e.g.*, the names of liqueurs, which have mostly a taste uncongenial to European palates, are legion. They are mostly mixtures of so many vegetable extracts that they have the character of the most tasty drugs which could be mixed together from the medicine loft of an ancient Dutch droogery.

Liqueurs are frequently offered at a price which amounts to five or six times the value of their ingredients. At some places of restauration a little glass of liqueur, containing two thimblefuls, is marked one shilling on the list of prices. Such values diminish the otherwise deserved popularity of these confections.

WATER AND WATER SUPPLIES;

AND

UNFERMENTED BEVERAGES.

BY

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INTRODUCTION.

To quench thirst and to satisfy hunger are the first-born instincts of animal nature. They begin with life, they are co-extensive with life. At first these desires are mere desires, and with the mere animal they so remain. With man, however, instinct and insight go hand in hand. He looks into the inherent qualities of what he eats and drinks, seeks to know something of the action of the foods and fluids, and is anxious to be assured of their purity and efficiency. To the more earnest of such inquirers into the natural and general qualities—not of solid food but—of beverages, this Handbook is especially addressed. Questions respecting solid food will be answered elsewhere. Indeed, the class of *alcoholic* drinks will be treated in a separate manual. Water, aërated beverages, those called tea and coffee, with some similar unfermented fluids, and even cocoa, chocolate and milk, will be fully considered in the following pages.

Section I. treats of Water and Water-Supplies ; Section II. includes Mineral Waters and Aërated Beverages ; Section III. is devoted to the Purification and the Analysis of Water ; in Section IV. are grouped Tea, Coffee, other "Teas," Cocoa, Chocolate and Milk.

The Handbook is written at the request of the Executive Council of the International Health Exhibition, held in London in 1884.

J. A.

17, Bloomsbury Square, London,
May 1, 1884.

CONTENTS.

SECTION I.

WATER AND WATER-SUPPLIES

CHAPTER I.

WATER.

CHAPTER II.

WATER, CONTINUED.

CHAPTER III.

WATER, CONTINUED.

CHAPTER IV.

NATURAL WATER-SUPPLIES.

CHAPTER V.

NATURAL WATER-SUPPLIES, CONTINUED.

CHAPTER VI.

NATURAL WATER-SUPPLIES, CONTINUED.

SECTION II.

MINERAL WATERS AND AËRATED BEVERAGES.

CHAPTER I.

MINERAL WATERS.

CHAPTER II.

ARTIFICIALLY AËRATED WATERS.

SECTION III.

WATER-PURIFICATION AND ANALYSIS.

SECTION IV.

OTHER UNFERMENTED BEVERAGES.

CHAPTER I.

TEA.

CHAPTER II.

COFFEE.

CHAPTER III.

OTHER "TEAS."

CONTENTS.

WATER AND WATER-SUPPLIES;

AND

UNFERMENTED BEVERAGES.

SECTION I.

WATER AND WATER-SUPPLIES.

CHAPTER I.

WATER—ITS RELATION TO HEALTH—COMPOSITION—NATURAL HISTORY.

WATER is the basis of all beverages. Even when used as a vehicle for carrying alcohol into the system, or for conveying the stimulating principles of tea and coffee into the body, or as a medium for nourishing matter, the water of the resulting beverages, in so far as they are beverages, is what satisfies thirst; it is the water that supplies the wants which assert themselves in the desire termed thirst. In dwelling on this fact for a moment, let us take an illustration from the class of stimulating beverages. A tea-cupful of tea, as poured from the tea-pot, is almost wholly water. It does not contain more solid matter dissolved from the leaves of the tea than would add a wafer-like covering to a shilling. No doubt that wafer is extremely potent, and has important stimulating functions to perform, as will be pointed out presently; but so far as the cheering cup is a beverage, so far water makes it a beverage and gives it properties not imparted by any other fluid. Another illustration, this time from nourishing beverages. In half a pint of genuine milk all but about a table-spoonful is water. That table-

spoonful is invaluable as nourishment, but so far as milk satisfies thirst it does so by virtue of the water which forms seven-eighths of its bulk. In short, not only is water itself the prime beverage of life, but the one foundation of all thirst-allaying beverages. Aqueous fluids alone quench thirst, water alone satisfies this craving—a craving common to man and all animals; nay, looking no further than the drooping of leaves during drought and their comparative firmness and flexibility after rain, a craving as irresistible, apparently, in the vegetable as in the animal kingdom.

Whence comes our periodical desire to drink water or water-containing fluids? It may be said to arise from an inbred necessity for the maintenance of the composition and function of every tissue in the living frame. The brain, the heart, the lungs, the muscles of the arms and legs, every organ has its normal and natural proportion of water. Even bone contains much water. In a man of average weight, say 140 pounds, quite 100 pounds is water. Water contributes to the flexibility, extensibility, and contractility of the limbs and the more vital organs. Further, it is the medium which conveys food and its products to and from every part of our system. Not more certainly is the merchandise of the world carried to and fro by its water highways, or the waste of the world carried down its rivers to the sea, than is the food and waste of the microcosm called man carried to and fro his frame by the watery fluid in his veins and arteries. Similar remarks may be applied to animals generally; and to the vegetable kingdom. A block of cut wood, straw, hay, wheat grains, rice, etc., contain only 12 to 15 per cent. of water; but the living structures of potatoes, green peas, apples, parsnips, and the whole plant of clover or growing rye, contain 75 to 85 per cent.; cabbage, carrot, French bean, mangold, onion, turnip, 85 to 90 per cent.; lettuce and water-cress 95; and grapes, peaches, and strawberries a still greater amount of water. The presence of a due proportion of water in every animal and every vegetable is obviously an indispensable condition of health and of life.

To obtain a thorough knowledge respecting beverages, a thorough study of water is indispensable.

Just one reflection before proceeding to that study. When all in man that is dear to man has left man's mortal frame, his body is placed in the ground. There, only too commonly, its hundred pounds of water slowly convey its forty pounds of other matter, mostly as loathsome and poisonous products of decay, to those wells and water-courses, which afford us one of the prime necessaries of life, namely pure water, and which, therefore, should be jealously guarded from any such dreadful contamination. Sooner or later, no doubt, but possibly after much mischief is done, the harmful products of decay are converted into harmless gases. Contrast this picture with another. In the course of a couple of hours, by a more ancient and more simple process than that of burial, the body might be converted into the selfsame gases, with ashes preserved instead of distributed, and without the intermediate risk of the dead doing such terrible harm to the living. How much longer will a misguided sentiment, an ill-guided superstition, or simple ignorance, sanction the poison-breeding process of interment, when the highest religion and the best interests of humanity point to the harmless practice of cremation?

History of the Composition of Water.—The history of water up to a date so recent as 1782 is the history of its obvious physical properties and uses. Those properties and uses will presently be described; but to write their history, even regarding water only as a beverage, would be to write a part of the history of civilization and of human instincts. Such treatment would be out of place in this Handbook, as it would be beyond the powers of the author. A few sentences may, however, be given respecting the history of the question of the composition of water.

France and England have contended for the honour of having first discovered the composition of water. But while all allow that Lavoisier first showed how water could be decomposed into its elements, to Cavendish and to Watt

must be awarded the merit of having previously shown how it could be composed from those elements. As between Cavendish and Watt there can now be little doubt, thanks to the testimony of De Luc, a countryman of Lavoisier, that while Watt—James Watt, the great engineer—in 1783 gave the first satisfactory account of the composition of water, Cavendish—the Honourable Henry Cavendish, the younger son of Lord Charles Cavendish—in 1782, if not earlier, first demonstrated by experiment that hydrogen and oxygen, being mixed in due proportion and properly united, were entirely converted into water. Dr. George Wilson, in his *Life of Cavendish*, writes as follows: "For Cavendish I claim that he was the first who observed and inferred that water consists of hydrogen and oxygen; and to Lavoisier I assign the merit of having simplified and perfected Cavendish's conclusion, and of having been the first to prove the composition of water by analysis. I acknowledge Watt to have been an independent and original theorist on the composition of water, and to have largely contributed to the dissemination of the true theory of its nature." Cavendish first discovered the composition of water, by synthesis. Lavoisier afterwards proved the composition, by analysis. Watt confirmed the discovery. Equal honour to these three great men, each of whom, with equal zeal and singleness of purpose, was seeking after truth, if haply he might feel and find and with reverent courage draw aside the veil that hitherto had hidden that truth from all eyes; and it is certain that either would sooner or later have made the great discovery. For that was the time when the art of obtaining elements from compounds, and of making compounds from elements, was just bursting into activity; the period when those three men, with Scheele and Priestley, and others in various parts of Europe, were applying methods of research that must necessarily, as we now see, result in such discoveries. A true system of chemistry, that is to say, chemistry as a definite art and as a science, resulted from these labours, and, not long afterwards, from those of men like Dalton and Davy. No doubt

very many of the facts and operations we now term chemical have been known as isolated items of knowledge for centuries. Thus, the ancient Egyptians made glass, soap, and vinegar; and the Greeks started the idea that matter was composed of a few elements, imagining earth, air, fire, and water, to be elements. But the true relation of elements to compounds and compounds to elements, and the great general principles which interlace and bind together separate facts, the principles which from their extensive application and importance are denominated *laws*, have been brought to light since the year 1770. Chemistry as an art and a science is little more than a hundred years old.

Composition.—Water, then, is composed of the elements oxygen and hydrogen—called elements because by no known means can we further divide, break up, or decompose these and the sixty to seventy other similar bodies of which all terrestrial and, as far as we know, celestial matter is formed. Both oxygen and hydrogen are now perfectly familiar to chemists and other specialists, though not to the general public to whom this Handbook is addressed. For although one-fifth of the air we breathe is free uncombined oxygen, and although this element forms the life-sustaining part of the air, nearly four-fifths of the air being mere diluting matter, it is invisible, inodorous, and tasteless; and an element having these negative properties, and being so regularly inhaled that we scarcely ever take note of its entrance or exit, is too intangible and unobtrusive to enable all to realise its true characters. The majority of people are still less intimate with hydrogen. For it also is an invisible gas and, unlike oxygen, does not ordinarily exist in the free state in nature. In the combined state, however, besides being a constituent of water, it forms part of coal, wood, fats, oils, etc., and hence, is extremely useful to us when we require artificial heat or light. Oxygen is easily obtained in the free condition, by heating one of the many substances in which it is contained. Hydrogen also is readily produced in the free state when water, zinc or

iron, and a strong acid are brought together. Each may be collected in indiarubber bags or other receptacles by aid of tubes communicating with the generating vessels. The diluted oxygen in the air being the element which supports the combustion in our fires and flames, lamp or candle, pure undiluted oxygen is used, as might be expected, when intense fires or flames are wanted for manufacturing or other purposes. Free hydrogen is sometimes used for inflating balloons, for, although more expensive than coal-gas, it is much lighter; indeed, it is the lightest material known to us.

The foregoing few words will perhaps enable the reader to understand the general nature of the two elements of which water is composed. Should more thorough familiarity be desired, the preparation of a gallon of each of the elements, with the aid of an expert, is recommended, as well as the subsequent performance of a few experiments with each of these gases. Prominent among the experiments let two volumes of hydrogen and one of oxygen be mixed in a small strong dry bottle—a soda-water bottle—and a flame be applied to the mouth of the vessel. Some noise follows, and the sides of the bottle are bedewed with moisture—water. This was Cavendish's famous experiment, a special bottle quite closed being employed, and the mixture being ignited by an electric flame passed between the ends of two wires fixed into the sides of the bottle. Conversely, pass a current of electricity from an ordinary battery through water, by properly immersing the ends or poles of the battery in the fluid. From one pole oxygen is obtained, from the other hydrogen. To every volume of oxygen there will be obtained two volumes of hydrogen. Thus is the composition of water proved both synthetically and analytically. It yields two volumes of hydrogen and one of oxygen, it is produced from two volumes of hydrogen and one of oxygen. If the volumes happen to be wine-bottlefuls, each such quantity of hydrogen will weigh about one grain, and the wine-bottleful of oxygen will weigh sixteen grains for oxygen is sixteen times heavier

than hydrogen. There will be two wine-bottlefuls or two grains of hydrogen and one wine-bottleful or sixteen grains of oxygen; by weight, two of hydrogen to sixteen of oxygen or one to eight. In other terms, nine tons of water are composed of one ton hydrogen and eight tons oxygen.

It was necessary to state thus much respecting the elementary composition of water for two reasons. First, because of the extreme interest of the facts themselves; portions of the sum total of truth which need not the support of mere belief, but are demonstrable at any time by any man. Secondly, because the inquirer into the true nature of beverages must be prepared to learn that a part of the water taken into the systems of animals or vegetables ceases to be water, its elements uniting with other elements to form the growing individual, and only reuniting to form water when the animal or vegetable tissues are burned: burned rapidly in our fires and flames, as oil or wood, etc., less rapidly in our own frames in the form of that portion of food which maintains our warmth, and very slowly in the process of slow decay.

In connection with the composition of water, attention may be directed to one more truth of far greater importance for its own sake than for the slender connection it has with water regarded as a beverage. It has been stated that water is composed of eight parts by weight of oxygen with one of hydrogen; say eight ounces, that is, half a pound of oxygen with one ounce of hydrogen, forming nine ounces of water. These are round numbers. It would perhaps be more correct to say that one hundred thousand pounds of water (ten thousand gallons, or a cistern nearly eight yards long, eight wide, and one yard deep) are composed of 88,864 pounds of oxygen to 11,136 pounds of hydrogen.* Not 88,865 pounds of oxygen nor 88,863 pounds, but *exactly* and *always* 88,864. Here absolutely no variation is permitted. When we mechanically mix things, which we do every day of our lives, the proportions are quite subject to our will or judgment. We may mix a few leaves more

* $H = 1$; $O = 15 \cdot 96$.

or less of tea with a quart of boiling water; we may put more or less plums into a pudding; even bronze pennies may contain somewhat more or less of copper on the one hand or of tin on the other and still be bronze. And given unlimited amounts of oxygen and hydrogen we could produce unlimited *amounts* of water. But with regard to *proportions* the limit is absolute. Let the attempt to use other proportions be made. Bring together, under proper conditions, 11,136 pounds of hydrogen and 88,864 pounds of oxygen with one single pound more of oxygen, namely, 88,865. Nature is not beaten. She will combine the 11,136 pounds of hydrogen with 88,864 pounds of the oxygen, giving the total of 100,000 pounds of water, and the single pound of oxygen, added in rash contravention of her rule, will remain behind as a single pound of unaltered oxygen. Use a pound *less* of oxygen and a corresponding quantity of the hydrogen will remain behind unaltered. The combining proportions of oxygen and hydrogen are fixed and invariable—invariable, that is to say, if we desire to mix them not simply by the aid of mechanical force, so as to produce a quantity of merely mixed gases, but to mix them by aid of the chemical force so as to produce water. Not only so. To *every* element nature once for all has given a combining number, fixed and invariable. The commandment respecting this invariability in composition of the substances forming the matter which surrounds us and of which we are ourselves formed, one of many such great commandments, has gone forth; a commandment that needs not the support of faith or trust, for its existence can be demonstrated by any man at any time. A wise commandment too, for it is difficult to conceive of the possibility of life were such matters subject to human control.

Natural History of Water.—Water occurs in the air, in animals, and in vegetables, and on and in the earth.

In the air water occurs in variable proportions, both in invisible solution to the extent of one or one-and-a-half per cent. and as visible mist or cloud. When the propor-

tion of dissolved and invisible water is unusually low the air too rapidly abstracts moisture from animals and vegetables and has an unpleasant drying or parching effect. When the air is saturated with dissolved water (at a temperature of 80° F., two per cent. of water may be present) the moisture of our bodies does not pass away from our lungs, air passages, and external skin rapidly enough for health ; the always-exuding and invisible perspiration is then more than usually liable to condense on our skin as visible perspiration, and the air has a close and languor-producing or depressing effect. In cloud, or mist, or fog, water is apparently in the form of minute vesicles, very minute particles, which may remain suspended, or coalesce and fall as dew or as rain. When above us, or, indeed, when from the summit of a mountain we look down on these visible aggregations, we speak of them as cloud ; when they are at our level we term them mist or fog. These are differences of words only not of things. When clouds are on the hill tops and the valleys are clear, if we walk to the summits we shall find ourselves in what we shall no longer call cloud, but fog or mist, according as the visible moisture is greater or less in amount. The fog of towns is not unusually associated with the sulphurous and other invisible chimney gases and the visible smoke, that is, finely divided soot, which escape from dwellings, workshops, and factories. The temporary formation of visible cloud, and that more or less rapid solution in the air by which the particles become invisible, may be seen at any time in the track of a locomotive or in the puffs from a stationary engine. True vapour of water, actual steam, is invisible. The particles of water only become visible at a foot or so from the mouth of the funnel or steam pipe, when in fact the true steam has become condensed to visible cloud. When steam is issuing from the spout of a tea-kettle place a glass tube in the mouth. After a minute or so, when the tube has become hot, nothing will be seen within the tube, and only at the end or at a little distance from the further end of the tube, will the "cloud" of water particles show themselves.

Steam is an invisible gas; at the ordinary temperature of our atmosphere it simply is not a permanent gas.

Water in the course of precipitation from the air may fall as snow or hail, but strictly speaking the air only contains gaseous or vaporous or mist-like water.

The occurrence of water in plants and animals has already been alluded to. The exact cause of the ascent of water, commonly called sap in plants, has not yet satisfactorily been made out.

On the surface of the earth water occurs both in the solid and the liquid conditions. In the solid form as ice and snow it is more or less familiar to us during our winters. On the snow slopes and glaciers of the Swiss Alps, and on any heights of eight or ten thousand feet above sea level, ice may be studied in summer as well as winter in all its interest and beauty. Water is permanently solid in the polar regions; on the plains and at the sea-level as well as on the hills.

The liquid water on and in our earth may, for purposes of description, be thus classified:—1. Rain Water, including Dew. 2. Water as it occurs disseminated through the soil or slowly trickling to the roots of plants or to rivers, wells, and the great underground stores in the gravel, sand, chalk, etc. 3. Pond or Marsh Water. 4. Lake Water. 5. River Water. 6. Sea Water. 7. Spring Water. 8 Well Water. 9. Mineral Waters; warm, cold, and aërated. These will be treated with appropriate detail hereafter. In respect of the quality of natural waters as used in households the Rivers Pollution Commissioners in the sixth report (1868) adopt the following classification:

Wholesome	1. Spring Water	Very palatable.
	2. Deep-well Water	
	3. Upland surface Water	Moderately palatable.
Suspicious	4. Stored Rain Water	
	5. Surface Water from cultivated lands	palatable.
Dangerous	6. River Water to which sewage gains access	
	7. Shallow-well Water [to which sewage gains access]	

Finally, water in the earth occurs as an integral consti-

tuent of minerals; in some cases possibly decomposing into its elements and so ceasing to be water; in other cases parting with heat and becoming a solid component of a mineral, as a "hydrate," or as what is by chemists termed water of crystallization.

From the natural history point of view, also, water may rightly be regarded as a great solvent, slowly transferring such minerals as chalk and limestone and various saline matters from the earth into which it penetrates, to the ocean towards which it flows. It may properly be viewed, too, as a great mechanical disintegrating agent, ploughing out the channels of surface streams, and slowly, but surely, altering the landscape of a whole country.

We have no evidence of the existence of water deep down within the earth. Indeed, the increase of temperature observed as we descend would appear to preclude the occurrence of liquid water at great depths. Steam continuously issues from the ground in many volcanic districts.

The total stock of water in the world would seem to be the same now as ever. Some may, and no doubt does, become decomposed into its elements in plants and animals, apparently diminishing the total amount of water as water, but such structures soon mature and die, and the combustion to which they are then subjected, rapid in fires, slow in the earth, reconverts their hydrogen and the oxygen of them and of the air into water, and so the balance is maintained. Water is ceaselessly altering its position and condition, but it flows in a circle. We may commence our investigation of the circle at any point, but if we follow the portion on which we fix our gaze, we are brought again to the point whence we started. The rain falls, it aggregates to streams, they flow to the ocean, the ocean is slowly evaporated by the sun's heat to the clouds, and these condense and fall again as rain. The water man drank and used before, man will drink and use again, and again, and again, each time purified and fitted for its purpose in nature's own great and perfectly-appointed laboratory.

CHAPTER II.

THE PROPERTIES OF WATER.

Chemical Properties.—The properties of water are physical and chemical. The latter can only be described appropriately in a manual of chemistry. Water is indeed itself a chemical substance, and when mixed with any one of a large number of other chemical substances, the mixed bodies mutually decompose each other, fresh substances altogether being produced. Thus $75\frac{3}{4}$ parts of quicklime and $24\frac{1}{4}$ of water when brought together chemically combine and undergo entire alteration of properties. For, 100 parts of absolutely *dry* slaked lime results. The same proportions of sand and water mixed would give wet sand containing $24\frac{1}{4}$ per cent. of water, which would dry out on exposure to the air. No amount of such exposure would dry out any of the water from slaked lime, for indeed there is no water there, only the separate elements of water. By the way, the proportions in which water and lime thus chemically attack each other are fixed and invariable. Add, not $24\frac{1}{4}$ parts of water, but say, $25\frac{1}{4}$; the 100 parts of slaked lime will result, the one part of water in excess of nature's proportions remaining as watěr, giving that much of dampness to the slaked lime. Conversely to such disappearance of water as water, when its chemical properties come into exercise, is its sudden appearance when two different substances, each containing one of the elements of water, are chemically brought together. Thus, in making a half-pint seidlitz draught, tartaric acid and carbonate of sodium are consecutively stirred into the fluid. Hydrogen in the tartaric acid, and oxygen in the carbonate chemically unite at the moment they come into contact, and produce water. These two illustrations of certain chemical aspects of water will probably be sufficiently familiar to

the reader to enable him to catch a glimpse of the importance of the chemical relationship of water. On this head more cannot be stated in this Handbook. Fortunately, water is not a very active chemical body, indeed, it seldom acts chemically ; generally it is quite neutral. Neutrality, however, gives it exceptional value as, first, a medium for the conveyance of force, as in the steam-engine and the hydraulic press, and in introducing substances to each other which do act chemically ; and, secondly, as a medium for the conveyance of matter, whether on the water-highways of the world, in the vats and pipes of factories, or in the vessels, arteries, and tubes in plants and animals. The physical properties of water may now claim attention.

Physical Properties of Water.

Colour.—Water is not colourless ; it is blue, greenish-blue. The human eye is not sensitive enough to detect this colour in a glass of water, but on looking through a few feet of water the beautiful tint is clearly perceived. It is obvious enough on looking through a glass-capped tube ten feet long, if the water is pure. A mere trace, however, of other matter is sufficient to mask this colour. Thus peaty water, common on our moorlands, is brown, visibly brown in a half-pint tumbler. Ordinary peat water is harmless for drinking, but a tea-cupful in a gallon of pure water will quite obscure the delicate blue tint of the latter. Large bodies of water may be pure enough for drinking purposes, but are seldom sufficiently free from the traces of this brown matter dissolved from the grassy, mossy, or heathery surfaces on which the original rain falls, to display the blue colour of physically-pure water. Besides, such masses are commonly contained in natural or artificial reservoirs, the sides and bottoms of which are of dark colour, and do not reflect light enough to show the true colour of the water. When, however, a large cistern or reservoir of hard water has been softened in the ordinary way by adding the proper proportion of lime, the water is often sufficiently purified, even from the harmless traces of brown organic matter in solution, to exhibit the

normal blue colour of water. Moreover, the sides and bottoms of such receptacles become lined with the precipitated white calcareous products, and therefore reflect enough light to show the beautiful tint of the fluid. The lovely blue, or greenish-blue colour of water thus softened and purified, may be seen by any passenger on the London and North-Western Railway a few yards to the east of the line on the Watford side of Bushey station. The precipitating reservoirs of the Colne Valley Water Company are there on a lower level than the railway, and can be looked into from the windows of a passing train. A visit to an ice cavern in a glacier, quite practicable for ladies and children in more than one place in Switzerland, will enable the colour of masses of solid water to be seen, and reveal to the eye azure tints of beauty never to be forgotten.

Odour.—Pure water is odourless, at all events to man. The camel detects waters when still at a considerable distance; but whether the animal truly scents it by some inherent odour properly so called, or by the delicate nerves of its nose or mouth perceives the necessarily somewhat less arid nature of the atmosphere it is penetrating, is not known.

Flavour.—To say that pure water or even recently-boiled and cooled ordinary water is flavourless would scarcely convey a right idea. It would be better described as insipid, not to say mawkish. When such water is freely exposed to the air it re-absorbs the gases of the air, chiefly carbonic acid gas, and then has the usually refreshing effect on the palate.

Softness.—To the sense of touch pure water is soft. When the fingers are rubbed together beneath the surface of such water they glide smoothly over each other. This softness is not interfered with by the presence of dissolved gases, or by the dissolved smoke and soot often present in rain water collected in towns. And even a few grains per gallon of saline mineral substances do not materially reduce the softness. Calcareous and magnesian compounds, however, so commonly present in the variety of good drinking

water which has passed through many yards of earth on its way to wells or other reservoirs, if present to the extent of more than three or four grains per gallon, give a distinct and opposite character, appropriately termed hardness, to water. Rubbed together beneath the surface of such water the fingers pass over each other with difficulty and with somewhat of harshness or roughness, quite familiar to those who use hard water for ordinary washing purposes.

Weight of Water.—A gallon of pure water, if at the standard temperature of 62° F., weighs ten imperial pounds, ordinary avoirdupois pounds. Should the temperature of the water in the accurately-filled perfect gallon measure then rise, the water, like every other substance in nature, will expand, a portion will flow away, and the gallon will then weigh less than ten pounds. Should the temperature, on the other hand, fall a few degrees below 62° F., the water in the measure, like every other substance in nature, will contract; more water must be poured in before the measure is again a full gallon, and the gallon at the lower temperature will weigh more than ten pounds. Hence, in heating water, if we start from thirty-nine or forty degrees F., 1000 gallons will expand to 1043 gallons before the boiling point is reached. It need scarcely be added, that one gallon of water near the boiling point will weigh little more than 9½ pounds.

Expansibility. Weight of Cold Water and Ice.—Water is a partial exception to the rule that all bodies expand when heated and contract when cooled; for, from what has already been stated, it will be seen that even water itself follows the rule under most circumstances. The exception occurs when water freezes and while it is exposed to the first seven degrees above the freezing point. In falling from about 39 degrees to 32° F. water not only does not contract, but it expands. One thousand gallons expands so unmistakably in passing down through these few, 7½, degrees, that from a vessel exactly holding that quantity at 39½ degrees quite a pound of water would

escape and flow away by the time the temperature of 32° was reached—in falling through 7½ degrees at any other temperature water would follow the usual rule and contract to about the same extent. The importance of this fact to health is incalculable. The surface of all water in winter expanding when once it is cooled to 39° F. the superficial portions become lighter than those below, therefore *remain* on the surface, the lower portions no longer rise to the surface, no longer become cooler and cooler, no longer suffer radiation of their heat into space, and thus the temperature of our earth is kept from approaching the low point at which life would cease. For, these vertical currents within lakes, seas, and large bodies of water, are the chief agents of the transference of the warmth of the earth to the colder surface in winter, still water being a very bad conductor of heat; as will be seen presently. The ice and snow on the ground is equally still, of course, and being an equally bad conductor of heat with fluid water, equally well keeps in the warmth of the earth during winter. Snow, ice, and water at the temperature of 39° to 32°, act like a blanket, therefore, keeping warm the earth and so prevent it becoming uninhabitable.

Fill two or three wine bottles to the brim with cold water and place them on the cold ground during the strong frost of a winter's night. In some the water may first freeze in the neck, and afterwards freezing and expanding below will inevitably burst the bottles. In others the water may first freeze at the bottom, and afterwards, gradually freezing and expanding upwards, will force out layer after layer from the neck, each layer freezing as it becomes exposed to the air and pushing up the layer of ice above it, until, in the morning, a rod of ice nearly as long as one's finger will be found protruding from the mouth of the bottle. A one gallon measure of ice-cold water would thus lose nearly fourteen ounces, and the gallon of ice remaining in the measure instead of having the normal weight of ten pounds would weigh under nine pounds three ounces. Ice being that much lighter than water floats on

water, and not only renders life possible on this earth by contributing to the maintenance of the warmth of the earth in the manner already described, but even adds to the pleasures of life, by enabling us to slide, skate, and otherwise amuse ourselves on its smooth and slippery surface.

The expansion of water in freezing is almost irresistible. A bombshell filled with cold water, duly plugged, and exposed to the cold of a Canadian winter for a few hours, is inevitably cracked or burst in pieces. Our own less severe temperatures in Great Britain are ample for the bursting of lead, iron, or earthenware pipes, with the too common result of damaged walls, floors, or furniture, when the thaw comes. Brickwork run up during frost may have the water in its mortar frozen, the particles of the mortar being inevitably separated from each other and from the bricks, instead of interlacing with each other, and within the brick pores, as mortar normally should, with the not infrequent result of the carcases tumbling down when the temperature once more rises. But the harm occasionally done to the householder, or to the unwise builder, is unworthy of serious notice, in view of the good done by this operation of nature to the farmer and gardener, and through them to the community. For clods of earth and hard food-yielding minerals, previously permeated with the winter's rain, are split and disintegrated by the winter's frost in a manner that neither spade, plough, nor hammer could accomplish, and thus are made to yield their stores of riches for plants, animals, and man.

Elasticity.—The elasticity of water is very slight. It is almost incompressible. A thousand gallons, subjected to a pressure equal to that of a second atmosphere, about fifteen pounds per square inch, would only be reduced in bulk to the extent of about one-third of a pint. This almost complete incompressibility of water renders it a valuable medium for the conveyance of pressure. In the powerful instrument, now so familiar to manufacturers and engineers under the name of Bramah's hydraulic press, the

pressure exerted on a piston of very small sectional area is conveyed by water to a piston or ram of large sectional area, the force being multiplied to exactly the relative extent of those areas, an enormous increase of the initial force being thus quite easily obtained.

Conduction for Heat.—Water is a bad conductor of heat, that is to say, heat very slowly penetrates a mass or body of still water. The heating, or conversely, the cooling of water is accomplished by currents set up within the fluid, heat being thus carried or conveyed by the currents. In this way water is heated by the access of heat to its surfaces or cooled by the escape of heat from its surfaces. It is thus that a kettle of cold water is heated or a kettle of hot water is cooled. If cold water be heated, or hot water be cooled, in a glass instead of a metal vessel, say a common Florence oil flask, and a few fragments of bran be placed in the water, the track of the currents can be followed by the eye. The readiness with which lakes or other bodies of water become cooled to 39 F., and the extreme slowness with which the lower portions are cooled below that temperature, especially when once a layer of ice has formed, can now perhaps be more fully understood and realised.

Boiling Point.—The temperature at which water boils varies. If the great weight and consequent downward pressure of the atmosphere be removed from the surface of water in any vessel, the warmth of the hand is sufficient to make the water boil. Boil half a pint of water in a saucepan or other convenient vessel. Remove the vessel from the source of heat and place it under the receiver of an air-pump. After the first stroke or two the water will again boil. When, through cooling, it ceases to boil, remove pressure by pumping out more air, and the water will once more boil. The lower the pressure the lower the temperature at which the water boils. The amount of air above us varies, within certain limits, therefore the downward pressure caused by the great weight of the air varies, and hence, the temperature at which water boils, even at any one place varies.

It may rise to quite two degrees above, or drop to as much below, the 212 degrees marked on our ordinary thermometers as the boiling point of water. So that 212 degrees is the boiling point of water only at the average pressure of the air. The barometer is the ordinary instrument for ascertaining that pressure, or weight, of the air at any given moment—indeed, the word barometer means weight-measurer. When the barometer is at about thirty inches water boils at 212° F. Should the air pressure increase until it balances about $31\frac{3}{4}$ inches of the mercurial column of the barometer, the boiling temperature will be 215 instead of 212 degrees. If the barometric column fall to about 28 inches, 209 will be the boiling point of the water. In ascending hills, the amount, and therefore the weight or pressure, of the air above us continually decreasing, the boiling point of water becomes lower and lower. The water boils at about one degree lower for every two hundred yards of ascent, so that in fact the temperature at which water boils is a good, though not the best, measure of the height to which the observer has ascended. Any person who has been on the highest peaks of Switzerland may have seen water boil in the open air below 190 degrees, a temperature insufficiently high for the satisfactory cooking of food. On the highest mountains of the Alps (Mont Blanc, 15,781 feet, or Monte Rosa, 15,364 feet) water would boil at about 185 degrees; on the highest mountain in Scotland (Ben Nevis, 4406 feet) 203°; Wales (Snowdon, 3571 feet) about 205°; Ireland (Carran Tuel, 3414 feet) $205\frac{1}{2}$°; England (Scaw Fell, 3210 feet) 206°. We cannot descend far into the earth, and thus very materially increase the depth and consequent pressure of the atmosphere then above us, but the boiling point of water might thus be seen to rise four or five degrees, that is, to 216° or 217° of the ordinary (Fahrenheit's) thermometer. In steam boilers a pressure equivalent to many atmospheres is commonly attained, the boiling point of the water within being raised to an equivalent degree.

The extent to which pressure, as indicated by the

barometer, affects the boiling point of water is shown in the following Tables, by Regnault.

BOILING POINTS OF WATER AT DIMINISHED PRESSURES.

Boiling point.	Barometer.	Boiling point.	Barometer.	Boiling point.	Barometer.
° F.	Inches.	° F.	Inches.	° F.	Inches.
184	16·676	195	21·124	206	26·529
185	17·047	196	21·576	207	27·068
186	17·421	197	22·030	208	27·614
187	17·803	198	22·498	209	28·183
188	18·196	199	22·965	210	28·744
189	18·593	200	23·454	211	29·331
190	18·992	201	23·937	212	29·922
191	19·407	202	24·441	213	30·516
192	19·822	203	25·014	214	31·120
193	20·254	204	25·468	215	31·730
194	20·687	205	25·992	216	32·350

BOILING POINTS OF WATER AT INCREASED PRESSURES.

Pressure in atmospheres each 30 inches of mercury.	Temperature in degrees Fahr.	Rise in temperature for each additional atmosphere.	Pressure in atmospheres each 30 inches of mercury.	Temperature in degrees Fahr.	Rise in temperature for each additional atmosphere.
1	212·0	37·5	11	364·2	6·9
2	249·5	23·8	12	371·1	6·7
3	273·3	17·9	13	377·8	6·2
4	291·2	14·8	14	384·0	6·0
5	306·0	12·2	15	390·0	5·4
6	318·2	11·4	16	395·4	5·4
7	329·6	9·9	17	400·8	5·1
8	339·5	8·9	18	405·9	4·9
9	348·4	8·2	19	410·8	4·6
10	356·6	7·6	20	415·4	

At 25 atmospheres the temperature would be about 439°; at 30, 457°; at 35, 473°; at 40, 486°; at 45, 498°; at 50, 511°.

The use of a Papin's Digester, for raising the boiling point of water in cooking and manufacturing operations, has been long practised. It is a small boiler or cauldron, the lid of which fits accurately and can be screwed down. The temperature attainable is only limited by the pressure which the vessel can sustain. The apparatus has been known to us for more than 200 years as shown by the following record. "At a meeting of the Royal Society,

Decemb. 8th, 1680. Ordered, that a book intituled *A New Digestor*, or Engine for softning bones, &c., Written by Denys Papin, Doctor of Physick, and Fellow of this Society, be printed and published, *Chr*[istopher] *Wren*." The work was issued with the above title, and "containing the description of its *make* and *use* in these particulars: viz. Cookery, Voyages at Sea, Confectionary, Making of Drinks, Chymistry, and Dying. . . Printed by J. M. for *Henry Bonwicke* at the *Red Lyon* in *St. Paul's* Churchyard. 1681."

The boiling point of water can be raised to some extent by dissolving saline substances in the water. Thus, by common table salt the boiling point may be raised to 227° F., that is, 15 degrees; the fluid then being saturated with salt, containing quite forty per cent. The explanation is, that the salt and water have a great amount of adhesion for each other, and an increased amount of heat is necessary to overcome the adhesion.

Adhesion.—Water adheres to surfaces far more strongly than we might expect. If a dish of water be brought beneath a 6 or 7-inch pan of properly-balanced scales, and the pan be placed on the water, several ounces of weights will have to be placed in the other pan before the wetted pan will leave the surface of the water. Even then it is the cohesion of the particles of the water for each other that is thus roughly measured, for water will be found still adhering to the pan; the true adhesion of the water for the pan is obviously still greater. All persons must have noticed how readily a tea-cup slips on a dry saucer, and how the tendency to slip is reduced by a few drops of tea or other aqueous fluid placed in the saucer. The cause of this effect is the adhesiveness of the water. The familiar act of wetting the fingers to enable them to adhere better should enable us to realise the adhesive nature of water.

Capacity for Heat.—If a pound of mercury were heated in a saucepan over a fire, it would acquire a certain degree of warmth in, say, five minutes. The same degree of warmth would be acquired by a pound of water under exactly similar circumstances in two hours and a quarter, the

heat passing into the water at the same rate as into the quicksilver. In this greed for heat, hiding heat up within the fluid, water surpasses all other substances, as shown in the following Table.

SPECIFIC HEAT OF SOLIDS AND LIQUIDS.

Water	1000	Iron	114
Ice	900	Copper	95
Alcohol	660	Zinc	95
Ether	520	Silver	57
Nitric Acid	442	Tin	56
Sulphuric Acid	333	Mercury	35
Carbon	241	Gold	32
Sulphur	202	Platinum	32
Glass	198	Lead	31

These figures are relative. They may be regarded as showing the very different degrees of heat to be given to the respective substances before equal weights would become equally warm; or, conversely, the amount, so to say, of heat which would have to be abstracted from equal weights of all the substances before they would all be cooled down through a given thermometric interval. To look at them from another point of view, they may be regarded as showing the number of hours the substances would require to become equally cool or equally warm when placed under equal conditions. February is a cold month in Great Britain. If water cooled as rapidly as mercury, our ponds, rivers, lakes, and seas would become as cold in one day of February as they now do in the whole of the month. To what extent, therefore, the surface of our earth, which is so largely water, would become cooled at that rate in a month or in a single winter is difficult to conceive. Certainly the resulting temperature would never be felt by living animals or vegetables, for all life would cease long before the temperature was reached. Conversely, if water did not absorb and, so to say, lock up and hide from the sense of touch, or from recognition by aid of a thermometer, such an enormous amount of heat for very small rises of tem-

perature, the world would far sooner become hot under the summer's sun, would become rapidly hotter and hotter, and the tempering of climate would be unknown, if indeed life were possible at all. These speculations may perhaps facilitate the realization of the importance as regards health of the high specific heat of water as compared with all other substances. "One cubic mile of water in cooling through one degree warms 3076 cubic miles of air through four degrees." One cubic mile of water in becoming warmed one degree absorbs from 3076 cubic miles of air four degrees of heat. Hence, islands and coast lands have a more tempered climate than the more central portions of continents, hence is the whole earth kept habitable.

The "Latent" Heat of Water.—This in its nature and effects is closely allied to the specific heat of water, for it has to do with what is more or less philosophically termed the hiding up (*latens*, hiding) of heat by water. Place a large saucepanful of ice and water on a strong fire, a fire that would soon make a poker red hot. A thermometer will show the temperature of the mixture to be 32 degrees. After ten or twenty minutes, or when, after stirring, the ice is not quite all melted, take the temperature again. It is still 32 degrees. What has become of all the heat that has gone into the saucepan? We might give the philosophical answer that the heat has all been converted into motion, the particles of water having become correspondingly more active. It will suffice for present purposes, however, to say that the heat has become latent, using that word in quite a general sense. The heat has become hidden. For the important point to which attention is now drawn is, that water has a very high latent heat. The amount of heat that would liquefy a pound of ice would suffice to raise a pound of ice-cold water through about 142 degrees, whereas the amount of heat that would raise a pound of mercury through 5 degrees would suffice for the liquefaction of a pound of solid mercury. Or if the latent heat, or *heat of liquefaction*, of water be taken as unity, or 1000, the heat of liquefaction of mercury would be

represented by the number 35. In the following Table the latent heat of other substances is given.

Latent Heat.	Degrees Fahr.	Water = 1000.
Water	142·65	1000
Nitrate of Sodium	113·34	794
Nitrate of Potassium	85·26	598
Zinc	50·63	355
Silver	37·92	265
Tin	25·65	179
Cadmium	24·44	171
Bismuth	22·75	159
Sulphur	16·85	118
Lead	9 65	67
Phosphorus	9 05	63
Mercury	5·11	35

The benefits resulting to the health and comfort of man, consequent upon this property of solid water to take into itself or hide large quantities of heat in the course of liquefaction, will be obvious after what has been stated respecting specific heat. Were the latent heat of water as low as that of mercury, the ice of the Alps would become after a short period of sunshine a rushing torrent, which nothing in the valleys could withstand. Again, the earth, and consequently the air, would soon become too hot for life. But farther speculation is unnecessary. The setting in of frost is accompanied by the giving out of heat, and so the severity of winter is mitigated. The giving of the frost is accompanied by the absorption, or locking up, of heat, rendering the occurrence of floods exceptional.

Not only when water passes from the solid to the liquid condition, or from the liquid to the solid, is there great absorption of heat on the one hand, or emission on the other. When it passes from the liquid to the gaseous condition, or again when steam is condensed to water, there is similar absorption or emission of much heat. During the conversion of one pound of steam at 212° into one pound of water at 212° as much heat is given out as would suffice to raise about 967 pounds of water one degree. The latent heat of water vapour being represented by this number, 967; that of

alcohol would be about 370; ether, 163; turpentine, about 130; the element iodine, 43.

Expansibility in passing to the vaporous condition.—During the boiling of water one volume of the water gives 1600 volumes of steam. The heat of a high pressure boiler still further expands the resulting steam. This almost irresistible expansion is the source of the force of our steam-engines. The expanding steam presses forward a piston, the piston turns a crank, the latter acts on the wheel, the wheel gives the desired force or motion.

Water as a Solvent.—The solvent powers of water are too well known to need more than a passing reference. Moreover, they will necessarily come under notice when tea, coffee, milk, etc., are considered. The varying solubilities of gases in water, and the law relating to their solubility when the gas and the water are under pressure, will be referred to in connection with aërated waters. Salt is dissolved from mines by water, the insoluble clay being left behind. The saturated brine raised by pumping is subjected to heat, whereby water is evaporated and pure salt obtained in the familiar masses of minute crystals. Or sea water is evaporated, its salt deposited, the supernatant brine being drawn off together with all other undesirable saline matters still in solution. Sugar is deposited from its solution in the juice of the sugar-cane, etc., on the removal of some of the water by evaporation. The deposited sugar is purified by re-solution in water and re-deposition. Epsom salt, and very many saline medicines, are obtained by similar processes, in which the solvent power of water comes into exercise. In pharmacy there are employed many infusions resembling "tea," many decoctions resembling "coffee," emulsions not unlike milk, extracts like Spanish liquorice, mixtures like the semi-fluid breakfast beverages termed cocoa and chocolate; all obtained by aid of the solvent or semi-solvent action of water. Some substances, such as, for instance, chalk, are almost insoluble in actual water, but are slowly dissolved by the agency of the carbonic acid gas always present in ordinary water. Most substances are far more soluble in hot water than in cold. There are,

however, a few exceptions to this rule. It has already been stated that the boiling point of water is raised by dissolved salts ; the freezing point of such solutions is lower than that of pure water. Thus, the freezing point of sea water is lower than that of fresh water. When a bucket of sea water is sufficiently exposed to loss of heat to partially freeze, the ice formed is pure water ice, it contains no salt, the portion still fluid containing of course an increased percentage of salt. Sometimes these crystals of ice may mechanically inclose some of the sea water, and will have a slightly salt taste, but if a clear crystal be selected, and especially if its surface be washed with a little fresh water, no salt will be detected. The ice of icebergs is practically the ice of pure water. Ice, as already shown, being lighter than pure water, it will of course be still lighter than sea water, one gallon of which weighs ten and a quarter pounds instead of ten pounds. It is not astonishing, therefore, that the tops of icebergs protrude considerably above the sea surface.

The adhesion between solids and water, which determines solution, usually diminishes with the temperature of the solution. Agitation of a solution by shaking or stirring promotes the separation of a dissolved salt from the water to which it adheres. Hence, if a clear solution is, on the other hand, kept perfectly still, the temperature at which the dissolved substance usually separates is often considerably depressed. When separation does take place, however, a comparatively large amount of the dissolved solid is deposited, and a rise in temperature usually occurs. The separation of ice from water is no exception. In winter a jug of clear water in a bedroom may fall below 32°, and yet no ice be formed. On pouring such water out into a basin a magma of small ice crystals and water results, and the temperature of the whole rises to 32°. The writer has more than once witnessed this phenomenon. It can be quite easily imitated with saline solutions. Oddly enough, when shaking or stirring does not cause the separation of the crystals from such a fluid, the dropping in of a solid crystal of the same substance as that in solution will at once start solidification.

CHAPTER III.

THE VARIETIES OF WATER.

FOR purposes of description the varieties of water may be regarded as belonging to four classes :—Chemically-pure Water, Distilled Water, Natural Waters, and Artificially-aërated Waters. These will now be treated of, the paragraph on chemically-pure water being succeeded by some pages devoted to the consideration of the gases and solids which occur dissolved in the water of the other three classes.

Pure Water.—The words *pure water* are used in two distinct senses. The scientific chemist uses them to describe *water which is nothing but water ;* the public and the scientific chemists too use them to describe *water which is not impure*, but which may contain small quantities of many harmless, nay useful, dissolved solid and gaseous substances. This is a point of little moment, the context of the words, whether spoken or written, commonly indicating whether one or the other meaning is attached. Indeed the single word *water* itself is in similar case. But it was necessary to draw attention to the point in order to introduce a statement that might otherwise cause alarm, or at least produce undue astonishment. It is, that probably no person has ever drunk a single half pint of *pure* water, that is, chemically-pure water. Probably not one person in ten thousand has ever seen chemically-pure water, and not one in a million seen more than a few drops bedewing the inner sides of a closed bottle. When Cavendish, or those who since have repeated his famous experiment (see page 540), closed up the two elements of water, namely, pure hydrogen gas and pure oxygen gas in a bottle, and ignited the mixture, a film of moisture was seen inside the glass ; and if the operation was several times repeated, a few drops were perhaps collected within the vessel. This was pure

water, though, indeed, we should make no mere trivial assertion if we said that, even this apparently chemically-pure water would contain traces of alkali dissolved from the glass, or would contain in solution traces of either free hydrogen, free oxygen, or even air, the presence of which is unavoidable by human manipulators. Grove, after much labour, succeeded in freeing water from air to such an extent, that it boiled with an irregularity that warranted him in stating that if water could be entirely divested of air, or rather, the nitrogen of the air, it probably could not be boiled, in the ordinary sense of the word, at all, but would be decomposed by the heat. He could never succeed in eliminating every trace of nitrogen from water. So that absolutely pure water, in an actually isolated condition, is unknown to us. For all practical purposes, however, even for those of exact chemical analysis, when water is thus produced from its pure elements, out of contact of air, it is pure water. Expose such water to the air and it will become charged with the gases—it would not be right to say with gaseous impurities—of the air, just as champagne or aërated water is charged with gas, though not to the extent to which they are charged. Let the pure water trickle through soil, just as rain trickles through soil on its way to a well, and it will become charged—it would not be right, except perhaps from a strictly chemical point of view. certainly it would not be right from the hygienic point of view, to say it will be rendered impure—with certain small quantities of harmless, possibly useful, saline and earthy substances. Pump into it carbonic acid gas, either before or after charging it with saline, sweetening, or flavouring matters, and it becomes an artificially-aërated water. It would not be difficult, by dissolving appropriate gases or solids in pure water, roughly to imitate sea water, mineral waters, or other natural waters.

The Gases and Solids in Ordinary Water.

Before considering the ordinary varieties of water, a few pages must be devoted to a description of those gaseous

and solid substances which always occur in such water; normal substances, in contradistinction to those abnormal substances which do render water impure and unfit for use, and which will be treated subsequently.

Gases.—Rain, and all natural water, is more or less charged with the gases of the air. Those gases are chiefly oxygen and nitrogen. Twenty-five gallons of water will contain about five pints of these gases. In every five pints of ordinary air there are nearly four of nitrogen to one of oxygen. But in water the oxygen of the air is more soluble than the nitrogen, so that the air dissolved by and contained in water, the air which fishes breathe by help of their gills, air which can without any great difficulty be boiled out of the water and be collected and examined, is composed, in every five pints, of rather less than two pints of oxygen to rather more than three pints of nitrogen. This fact gives rise to some interesting reflections, which cannot farther be pursued here, on the difference in the respiration of fishes and other animals; for the oxygen of the air being the supporter of respiration, the nitrogen being only the diluting agent, it is obvious that fishes breathe a more powerfully oxygenating and warmth-producing air than is inhaled by man. With regard to carbonic acid gas, rain does not appear to dissolve any very large amount from the air. Twenty-five gallons of lake water seldom contain much more than a quarter or half a pint of dissolved carbonic acid gas. Carbonic acid is readily soluble in water, far more readily than oxygen or nitrogen, but its proportion in the air is very small, only about four parts in ten thousand, hence the small proportion present in fresh rain water. Yet in ordinary river and well waters there is much carbonic acid. Twenty-five gallons of Thames water, for instance, commonly contains one gallon of carbonic acid gas in solution, a quantity that becomes increased as the river flows through London, or otherwise becomes much contaminated, carbonic acid being the harmless product of the destruction, that is, oxidation, of such contaminating matter. It is this oxida-

tion that is the prime cause of the occurrence of carbonic acid in such water. The animal and vegetable matter that gains access to all water that falls on and flows through ground, more particularly cultivated ground, matter which is, therefore, present in all river water, especially in the neighbourhood of towns, becomes oxidised or burned by the dissolved oxygen in the water, the product being carbonic acid gas. The action is not different to that by which such animal or vegetable matter thrown on to a fire would be burned by the oxygen of the air, the product being carbonic acid gas; it is only slower. Water thus deprived of its dissolved oxygen immediately takes up more oxygen from the air, and thus the action is maintained and the water becomes more and more charged with carbonic acid gas as it becomes less and less impure. This is the chief source of the carbonic acid in water. Nothing more need be said to show how important for health is the presence of dissolved oxygen gas in all water, especially if that water is to be used for drinking purposes. The presence of carbonic acid is scarcely less desirable, for it is to the presence of this gas that good drinking water owes its pleasant briskness or sharpness on the palate. Water from which the gases have been expelled, recently-boiled water, even when cold, is flat, insipid, and mawkish, and remains so until it has become aërated by exposure to air or by special means. Chemically-pure water is undesirable as a beverage. Twenty-five gallons of good well water or spring water may contain quite two gallons of dissolved carbonic acid gas. Certain natural mineral waters contain much larger amounts; a gallon occasionally holding more than a gallon of the gas in solution and effervescing as the water is drawn or escapes from the ground.

Calcareous Substances.—These are perhaps the commonest dissolved solid matters found in natural water. The chief forms are chalk and gypsum. Chalk is only soluble to the extent of two or three grains per gallon in chemically-pure water, but it is readily dissolved by the carbonic acid always present in natural water. The chemical name of

chalk, that which describes its composition, is carbonate of lime or carbonate of calcium. Ordinary limestone is a hard, opaque variety of carbonate of calcium. Marble is a crystalline semi-translucent variety. The chemical name of gypsum is sulphate of lime, or sulphate of calcium. Alabaster is a semi-crystalline variety; in the form of selenite it is still more crystalline and transparent. As dug from quarries and heated to form a cement, it is familiar under the name of plaster of Paris. The sulphate is more soluble than the carbonate, though far less soluble in water than such substances as sugar or salt. But it occurs less frequently than carbonate in the ground, hence is not often present in larger proportions than the carbonate in natural waters. The amount of calcareous substances in water varies from three or four-tenths of a grain per gallon in lakes surrounded by siliceous mountains, to fifteen or twenty grains per gallon in many well waters, especially those drawn from chalky districts, eighty or a hundred grains per gallon in a few mineral waters, one hundred to a hundred and twenty grains per gallon of the above and other compounds of calcium in sea waters, three or four hundred grains per gallon of various calcium compounds in one or two rare mine waters, and nearly two thousand grains or about four ounces per gallon in the waters of the Dead Sea. The calcareous compounds in water have been said to contribute to the formation of the bone of animals drinking the water, bone being a compound of calcium, but calcareous substances more nearly allied to that of bone occur in meat, milk, bread, etc., and to a greater extent than is required for the formation or renewal of bone. Probably the calcareous matters in water have no effect on the system, their total amount in the quantity and quality of water usually drank being insignificant. Even in districts in which they occur somewhat largely, no very obvious effect on those who habitually drink the waters can be traced. Either the systems of residents have become adapted to such waters, or the compounds have no special general effect even in the proportions of twenty or

thirty grains per gallon. "Chalk" gout is a misnomer; the small lumps of chalky consistence, which form in and on the joints of the patients, is not only not chalk but is not even calcareous; it is a compound of sodium, not of calcium.

Magnesian Substances.—These are as common as calcareous, but usually occur in very much smaller proportion. In well water two grains or one per gallon is a common quantity, occasionally a little more; the form being generally carbonate, with sometimes a little sulphate. These quantities appear to be insignificant in relation to health. A few mineral waters contain sulphate of magnesium, more generally known as sulphate of magnesia or Epsom salt; such waters are used as purgatives. Sea water contains three or four times as much magnesian as calcareous matter, namely, four or five hundred grains per gallon of chloride and sulphate of magnesium.

Salt.—Common salt, chemically termed chloride of sodium, occurs largely in sea water, one hundred parts of which contain nearly three of salt or about four ounces and a half per gallon. Many mineral waters contain salt. A few well waters, that is to say, those near the sea-coast or in the neighbourhood of such deposits of salt as occur in Shropshire and Cheshire, contain salt. Other well waters naturally contain either no salt or only two or three grains per gallon. A similar compound, chloride of potassium, may be present to the extent of a few grains per gallon, and sometimes a little chloride of calcium. Considering how much salt we eat every day, and that it is a constituent of our blood, it is clear that a little salt is, in itself, perfectly harmless in potable water. On the other hand, remembering that only a certain proportion of salt is maintained within our bodies as a natural constituent of the blood, and therefore that as much as we daily take into our frame daily passes out of it, if we find much salt in ordinary well water, which from the situation of the well ought to contain little or none, we may reasonably be suspicious of that water. And if that well water also is found to contain much more

than the normal traces of organic matter found in good water, we are justified in condemning it, as being contaminated by household sewage or similar objectionable matter. The significance of salt in this connection is, however, indirect; salt as salt is well known to be harmless by all who eat salt with their food.

Nitre.—Few waters are entirely free from one or other of the nitres—the potash nitre known as nitrate of potassium, saltpetre or sal prunella; the soda nitre, or nitrate of sodium or cubic nitre; the calcareous nitre, termed nitrate of lime or nitrate of calcium. The cause of the presence of a nitre in water is well known, and may be explained in a very few sentences. The statement has already been made that the stock of water in the world is a constant quantity; that rain falls on the earth and meets or may meet there with decaying vegetable or animal matter, which renders the water temporarily impure; that such water absorbs oxygen from the air especially as it passes through porous air-saturated soil; that this oxygen chemically attacks the impurities, oxidises them, as chemists say, converting them not only into harmless but useful substances; the purified water passing on its way to lakes and seas, there to be again evaporated into the air, again to be condensed as cloud, again to fall as rain, and so on in a perfect circle. Now, nitre is one of these harmless and useful substances, an oxidised product of the decay of dead vegetable and animal matter, certainly harmless and possibly useful to man or animals drinking the water, and certainly useful to the plants which imbibe such water through their roots, for nitre is a constant and, apparently, an indispensable constituent of all vegetable juices. Nitrogen is the characteristic element of most animal tissues and of some vegetable tissues; nitrogen is the characteristic element of nitres. That is to say, if either of the elements of such structures can be said to be more characteristic than another, nitrogen is that element. Carbon is as constant an element of both live and dead vegetable and animal matter, indeed, may be present in

materials, such as fat and sugar, from which nitrogen is absent altogether, but highly nitrogenous food is that which best enables animals and vegetables to thrive and do their work, and for this and other reasons nitrogen has come to be regarded as the leading element in the organic kingdoms of nature. Nitrogen is certainly a leading element in nitre; it is the element chiefly concerned in producing nitre; the word nitrogen in fact is derived from Greek words meaning generator of nitre. When, therefore, water containing dissolved oxygen comes into contact with animal and vegetable matters in a state of decay, their carbon is oxidised to carbonic acid gas, which, as it occurs dissolved in the water, is an indispensable article of food for subaqueous plants, and renders that water of brisk flavour and acceptable to man and all animals; *their nitrogen is oxidised to nitres, which remain dissolved in the water.* The nitre of the world may be a fairly constant quantity, but it is constantly being used up by plants, and by man in certain of his arts, and is constantly being replenished by the oxidation of dead animal and vegetable matter. When, through want of knowledge or of foresight in man, this oxidation is incomplete in any particular well or other reservoir of water, that water is impure and may be harmful, an important point that will be fully treated when the impurities of water are under consideration: it is the source of those small quantities of nitre that are nearly always present in good drinking waters that has now been described. A description, by the way, that will scarcely be palatable to the fastidious or the merely sentimental; those who do not recognise, or at all events realise, the absolute reign, throughout the whole of nature, of wise rules, or laws, or commandments. The enlightened see here, as elsewhere, the beauty of order and the perfection of government, whether as regards design or execution. Such facts as these serve to illustrate how each element in nature has its ceaseless round of work to perform. Each, too, does a fixed and invariable quantity of work, the work of each thus fitting in with the work of all the others. Not

more certainly does each of the sixty or seventy perfect notes of a perfectly-tuned stringed instrument of music vibrate at a different rate to the others, but in perfect harmony with them all, than does each of the sixty or seventy elements of nature do its work with a power special in kind and fixed in quantity but in perfect harmony with the power of all the others.

Siliceous Substances.—These are present in nearly all varieties of water; which might be expected, considering first, the power which water possesses to dissolve minute amounts of almost all materials, and secondly, the enormous surface of gravel and sand, both of which are almost wholly siliceous, and of siliceous soil generally, over which rain water must trickle on its way to wells or rivers. Siliceous substances are perfectly harmless.

Abnormal Substances.—Sulphates of sodium and potassium are also met with. In the small quantities in which such solids are dissolved in ordinary water they scarcely possess any interest. Traces of iron also are frequently detected. In very deep-seated springs ammoniacal salts are found, and carbonate of sodium.

The solid substances commonly met with in good water occasionally occur in very large proportions in mineral waters. Such waters are known as saline, aperient, alkaline, and calcareous waters. An excess of iron gives chalybeate water; of carbonic acid an acidulous water; while sulphur, especially in the form of sulphuretted hydrogen, gives a sulphurous water. Each of these will be considered hereafter. Very rarely the elements lithium, barium, strontium, manganese, bromine, and iodine occur in mineral waters.

Pure water, that is, water which is nothing but water, water in the abstract, having now been described, and some notice of the gaseous and solid substances met with in one or other of the varieties of water having been noticed, those varieties of water may themselves be considered, namely, distilled water, natural waters, and the artificially-aërated waters.

Distilled Water.

Boil a small quantity, say, half a pint, of water in a kettle until the steam escapes from the spout. Put a glass tube into the spout, the tube slanting downwards from the spout towards the floor. The steam will be seen to condense to a visible cloud in the tube, the cloud to condense to drops of water on the sides of the tube, the drops to coalesce, run down the tube and trickle from the open extremity. A little of the water may be caught in a wine-glass. That is distilled water. In preparing it on a large scale it is desirable that in the place of the glass tube in the above experiment there be one of metal, properly attached to the spout, and that the spout start not from the side of the kettle but from the centre of a securely fitting lid. The arrangement is then termed a still and condenser. The tube must be very long if an ounce or so of distilled water is to be collected. For economy of space the tube is usually coiled into a screw-like form or helix. Further, the coil, which rapidly becomes very hot, is usually placed in a tub, the extremity passing through a water-tight hole near the bottom, in order that, lastly, the condensing power of the coil may be maintained at a maximum by a current of cold water from a neighbouring cistern or other source (sea water or any *cold* water serves equally well) being made to flow into the tub, and, therefore, round the outside of the condensing tube. (This current, when the still is in action, will, of course, flow out of the tub as a useful stream of hot water.) From such a boiler, or still, and condenser, a supply of distilled water is obtained, its quantity only limited by the size of the apparatus.

The solid substances contained in the original water from which the distilled water was obtained, not being volatile, remain behind in the still or boiler. The gases contained in the original water are mostly driven out of the boiling water along with the first portions of steam, and for the most part escape into the air through the condensing pipe. A little air remains in solution in the distilled water,

but not enough to prevent it being flat and insipid. The latter character does not interfere in the slightest degree with the use of distilled water in manufactories, in chemical laboratories, and in manipulations with medicines in the surgeries of dispensing medical men and the pharmacies of dispensing chemists and druggists. In all these cases the absence of the solid substances in ordinary water is essential.

By free exposure to air, or, if necessary, by appropriate machinery, distilled water may easily be charged with the gases—oxygen, nitrogen, and carbonic acid—which render ordinary water so pleasantly palatable. It is then invaluable for drinking. Invaluable because, first, the mode of production guarantees the absence of those impurities which may contaminate well or river water, and, secondly, because distilled water is sometimes available where fresh spring water cannot be obtained. Should any slight flavour linger in distilled water, resulting from the action of the heat on organic matter in the original water, it may be removed by passing the distilled water through a cubic foot or two of charcoal. This treatment promotes the destruction of any such organic matter, by increasing the rapidity with which it is oxidised to carbonic acid, and thus also adds to the aëration of the water. On board the ships of Her Majesty's Navy, and on other steam vessels, where steam is a waste product, distilled water, properly aërated, is now largely employed for drinking purposes, a luxury indeed in comparison with the possibly ill-stored water of possibly doubtful origin of former days. Where steam is not a bye-product the cost of producing distilled water is considerable, for, as already explained in connection with the specific heat and latent heat of water, an enormous quantity of heat is absorbed during the conversion of cold water into hot, and hot water into steam, and the fuel for the production of this heat, and the manual labour involved, and the wear and tear of vessels cost much money, to say nothing of the fact that this heat has all to be got rid of again before cool distilled water can be obtained.

Yet the cost is not so great as to prevent the boon being taken advantage of under certain circumstances. In distilling water, the first portions should be thrown away, because they contain certain organic matters, or acids, or ammonia, resulting from the action of heat on solids not unlikely to be present in the original water, and which would render the water either unpalatable, unfitted for its uses, or liable to become slightly fermented or impure. The distillation should also not be carried on until the still is dry, because some of the residual solids, or the products of their reaction on each other, might be mechanically blown over into the distilled water.

Distilled water must not be stored in lead vessels or drawn through lead pipes, for lead is rapidly attacked by water not containing solids in solution, and enough becomes dissolved to render the water more or less poisonous. The use, also, of copper condensing pipes or copper storing vessels should be avoided, if possible, if the distilled water is to be used for drinking. The still itself may be of copper, iron, or earthenware; the condenser may be made of tin or earthenware. Stills and condensers of all sizes are common articles of trade.

CHAPTER IV.

NATURAL WATER-SUPPLIES.

Natural Waters.—These are :—1. Rain Water, including Dew ; 2. Water disseminated through the soil ; 3. Marsh or Pond Water ; 4. Lake Water and Upland Waters ; 5. River Water ; 6. Sea Water ; 7. Spring Water ; 8. Well Water ; 9. Mineral Waters ; warm, cold, and aërated.

1. *Rain Water and Dew.*—Of all natural waters rain water contains the smallest proportion by weight of dissolved substances, averaging from two to three grains per gallon. The first portions of rain which fall after dry weather contain, even in districts remote from towns, the dust of the district raised by wind, or dust and saline matter brought from a distance by wind. If a gale blow from the sea it may carry spray far inland, and minute crystals of the accompanying sea-salt may be detected by the microscope on windows against which the current blows, or chemically, in the first rainfall, sixty or a hundred miles from the coast. The first collections of rain near a town may also contain particles of soot or ashes. Collected from the roofs of houses rain may, too, contain twigs, moss, leaves, and products of the decay of woody tissues, as well as the dust of mortar and all kinds of impurities left by birds. Most of these substances will be in suspension in the rain water ; but in true solution, besides the saline matters from sea spray or from the lighter ashes discharged from chimneys, traces of hydrochloric acid and sulphuric acid may be present, products of chemical decompositions in factories, or, in the case of sulphuric acid, products of the combustion of sulphur, etc., in coals. After a thunder storm minute amounts of nitric acid may be found in rain, a product, probably, of the combination of the nitrogen and oxygen of the air under the influence of the electric

current. Ammonia appears to be a constant constituent of the air, and therefore is a constant constituent of rain water; usually in chemical union with one of the acids mentioned. Besides these solid matters, rain water contains the gases of the air, ten gallons holding in solution about a pint and a quarter of nitrogen, less than a pint of oxygen and about an eighth of a pint of carbonic acid gas.

When rain water is to be used for drinking purposes great care should be observed in its collection, storage, etc. Usually it will be collected from roofs. Trees should not overhang the roofs. The presence of birds should be discouraged. The roofs should be kept free from collections of moss, etc. Gutters should be periodically brushed out. Means should be provided for preventing the collection of the first runnings after dry weather. If arrangements can be adopted for filtering the supplies for drinking purposes through a cubic yard or two of clean red gravel, and afterwards through a cubic foot or two of charcoal, good well-aërated water may be obtained. Other filters may be used. Tanks should be above-ground and covered, or, if below, be of brickwork set in cement and plastered over or "floated" in cement. The use of lead-lined tanks and leaden pumps should be avoided, for soft water is liable to attack lead and dissolve enough to render the water harmful: an iron pump may be employed. In some dry countries the inhabitants are largely dependent on stored rain for their supplies of potable water, and when the reservoirs are small, crude, underground tanks, the water often becomes impure to a revolting degree.

Dew resembles rain water but usually contains somewhat larger proportions of solid matters, both in suspension and solution, the quantity commonly amounting to five or six grains per gallon. This is owing to its being deposited from the layers of air which, being nearest the earth, are most liable to be charged with light dust, or with the gases and smoke of chimneys, exhalations from manured ground, etc. Enormous quantities of dew are sometimes deposited, especially on or rather just within the surface of porous

soils, and particularly in summer, when the air, being very warm in the day, will hold most water in solution, and when the nights, being clear, allow of the warmth of the earth radiating away, and the deposition of the moisture on the thus cooled surface. During cloudy nights the heat of the ground is reflected back by the clouds and, consequently, far less moisture, or dew, can condense on the soil; in cloudy weather, however, obviously less dew will probably be required.

2. *Water Disseminated through the Soil.*—It is well known that rain does not at once pass through the ground on which it falls, flowing on until it reaches the lowest possible level, but remains suspended in or soaking the soil as in a sponge. This is partly due to the facts that the pores or minute channels of the soil are not always large enough to allow of the water getting away at once, and that the friction and consequent resistance between the water and the sides of the tortuous channels is so great that in overcoming it much time is occupied. But it is chiefly due to that great amount of adhesion which water has for the surfaces of solids, and which has already been alluded to on page 555. Minute pores or tubes such as those of the soil present very large amounts of surface to infiltering water, hence the relatively large amounts of water that can be retained within soils. Even the dissolved vapour of water contained in dry air is greedily absorbed by porous bodies. Weigh an ordinary overcoat that has been hanging in a hall for, say, twenty-four hours in fairly dry weather. Place it in front of a fire for an hour. Weigh it again. It will be found to have lost three or four ounces of moisture, or as much water as would fill two wine glasses. The amount will be much greater on a damp day. Soil thus absorbs moisture even from air not visibly damp. The power of porous bodies to absorb and retain fluids will be realised when one recalls the rapidity with which tea or coffee, etc., will rise up into and be retained by a lump of sugar placed in a table-spoon half filled with the fluid. Such capillary attraction (capillary, from *capillus* a hair)

may be still better demonstrated by using glass tubes as narrow as hairs. At summer temperatures in a wetted tube one twenty-fifth of an inch in diameter water will rise about an inch and a quarter, notwithstanding the gravitation of the water, when the end of the tube is placed within a drop of water or into a thin layer of water. A cubic foot of porous earth will readily take up and retain several pounds of water. The source of the large volumes of water necessary for the maintenance of the life of trees and plants during dry weather will now perhaps be understood; it is contained within the pores of the soil. One can now realise also why river beds do not rapidly fill during rain and as rapidly become dry soon after rain has ceased to fall; the adhesion of the water for the porous surfaces in the soil retards the flow down to the river that gravitation would otherwise very rapidly determine.

From the surface of the ground much water is directly returned to the air by evaporation. But much passes through the soil, being thus conveyed to the roots of plants, to ponds or marshes, lakes, rivers, and seas, and to the great underground stores into which our wells dip, and which sometimes burst out from the ground at lower levels, forming what are termed springs. Every drop of water thus flowing through the pores of the soil, and passing over an enormous amount of surface, has the fullest opportunity of dissolving from the soil whatever it is capable of dissolving. The names and characters of the dissolved gaseous, calcareous, magnesian, saline, and siliceous substances have been given on pages 562 to 569. The amounts in which they occur in the various natural waters will be described in the following pages. The conditions under which they are dissolved will now be realised, after what has just been stated respecting the porosity of soil, the great extent of the surfaces of the pores, and the manner in which every drop of water passes over a relatively almost unlimited amount of the soil.

3. *Marsh or Pond Water.*—Marsh waters are shallow collections of rain water, or, near the sea, of a mixture

of rain water and sea water. Such pools abound in vegetable growths of all kinds. From their shallowness they are soon warmed by the heat of the sun, and then ensues decomposition, fermentation, and decay of dead matter, overtaxing altogether the purifying power of the dissolved oxygen. The result is a fluid more or less charged with badly-smelling gases and dissolved vegetable matter, which, though small in amount, amounting sometimes to not more than five or ten grains per gallon, when no sea water is present, is in a state of change and liable to set up disease in those who incautiously drink or are more or less compelled occasionally to drink such waters. The dark-coloured peaty pools on mountains are far less liable to do harm, especially if the water is merely peaty and not much concentrated by evaporation.

A pond is a collection of water which varies in character from the water of a large pool in a marsh or swamp to the good potable water of a lake. It may be little else than rain water with five or ten grains per gallon of dissolved solids, soft for washing purposes, and fit for cooking purposes and for drinking. Pond water of this character is not often met with. On the other hand, it may be the mere diluted sewage of a farmyard, of a row of cottages, or of a village, disgusting alike to eyes and nose. If the water is desired for drinking and there is any doubt about the quality, err on the side of safety, and avoid the water if possible. In other cases, the opinion of a professional chemist should be obtained.

4. *Lake Water.*—The water of lakes is usually rain water which has fallen direct, or has first fallen on surrounding districts and then drained into the lake ; but it may be little else than river water, if the lake is the mere expansion of the local stream. The character of the gases and solids dissolved in it will vary in nature and amount according as the adjacent districts are more or less populated and cultivated ; according as the adjacent grounds, rocks, or hills, are of a calcareous or non-calcareous nature, the former being slightly soluble, but the latter almost in-

soluble in water; and according as the lake has or has not the more usual river outlet. In hot countries, especially if the ground be volcanic or highly saline, and the water draining into the lake does not escape in volume as a river or by soakage, but only by evaporation, the water becomes highly charged with salts. The best known illustration of a lake of this kind is the ancient *Lacus Asphaltites*, or so-called Dead Sea, in the south-east of the Holy Land near the borders of Arabia; but a more useful illustration would be the Elton Lake, in Russia, which is practically a saturated solution of common salt, annually yielding two hundred thousand tons of that substance. The so-called borax lake in California now contains no water at all, but is a collection of masses of common salt, glauber's salt, carbonate of sodium, borax, blue earth, etc., the residue of the former lake, from which the heat of the sun has evaporated all water.

ANALYSIS OF THE WATER OF THE DEAD SEA.

	Grains per gallon.
Chloride of Potassium	852
Chloride of Sodium	8477
Chloride of Calcium	1718
Sulphate of Calcium	46
Carbonate of Calcium	trace
Chloride of Magnesium	5475
Bromide of Magnesium	176
Chloride of Manganese	4
Chloride of Aluminium	39
Chloride of Iron	2
Silica	trace
Nitrogenous Organic Matter	44
Total dissolved solids	16,830
Water	65,210
One gallon, or grains weight	82,040

No less than one-fifth of the water of the Dead Sea, therefore, is solid matter. One gallon of pure fresh water weighs ten pounds or seventy thousand grains, one gallon

of the Dead Sea water weighs about eleven pounds and three-quarters or eighty-two thousand and forty grains. The chief of the salts mentioned have already been described, the others are of no general interest.

In Britain a characteristic of lakes is that they contain less dissolved solids than any other of our natural waters, in this respect standing out in strong contrast to the salt lakes just alluded to. Thus, Loch Katrine in Scotland, which supplies Glasgow with water, contains only about two grains of dissolved solids in one gallon; Thirlmere, in Cumberland, often less than two grains; Bala, in Wales, about two grains. This arises from the facts that, first, the lakes are surrounded by hills or mountains of such a height that the rain flows down their sides too rapidly to allow of much mineral matter going into solution; secondly, the rocks are mostly close-grained, not allowing of much penetration by rain; thirdly, the rocks contain very little limestone or other matter soluble in water; fourthly, the rain which passes over them contains very little carbonic acid, the chief solvent of limestone. The following Tables give (the first) the nature and amount of the gases dissolved in one gallon of Loch Katrine water, and (the second) the nature and amounts of the compounds, or, rather of the separate acids and bases obtained by chemical analysis, and which in a state of union form the salts or compounds, contained in one gallon of the water of Loch Katrine.

GASES IN LOCH KATRINE WATER.

(Cubic Inches per Gallon. One Gallon = $277\frac{1}{4}$ cub. in.)

Nitrogen gas	4·8
Oxygen gas	2·0
Carbonic acid gas	0·3
	7·1

The gases dissolved in our other mountain lakes are the same in kind and differ but little in amount.

MINERAL MATTER IN LOCH KATRINE WATER.

	Decimal parts of a grain per gallon.
Potash	0·030
Soda	0·224
Lime	0·512
Magnesia	0·153
Iron oxide	0·240
Sulphuric anhydride	0·462
Carbonic anhydride	0·393
Phosphoric anhydride	trace
Silica	0·123
Chloride of sodium	0·012
Total dissolved solids	2·149
Water	69,997·851
One gallon, or grains weight	70,000·000

These bases and anhydrides are in a state of chemical combination in the water. The compounds will be chiefly the sulphates of sodium and calcium. The whole of the solids yielded by five gallons of the water (10¾ grains) might be heaped on a threepenny-piece. The hardness of the water will be scarcely one degree per gallon, that is, such an amount as would in spring waters be produced by one grain of chalk; the water is, in fact, practically as soft as rain water. The solids in our other mountain lakes are the same in kind and differ but little in amount, as will be seen in the following Table adapted from data given in the sixth Report (1868) of the Rivers Pollution Commission. The Table shows not only the amount of dissolved solids, but gives an idea of the proportion of carbonaceous and nitrogenous solids, ammonia, chlorine in combination as chlorides, and the slight hardness of the respective waters. The average amount of solid matter in solution in such waters is so small that if ten gallons (sixty wine bottles) were evaporated over a fire until the water were all dissipated as steam the residual solid material (26 grains) might all be heaped on a shilling.

DISSOLVED SOLIDS OF LAKE WATER.

(The figures show grains or decimal parts of a grain per gallon.)

Lake.	Total solids.	Organic carbon.	Organic nitrogen.	Ammonia.	Nitrogen in nitrates.	Chlorine in chlorides.	Hardness. Temporary	Hardness. Perma-nent.	Hardness. Total.
Bala, July, 1867 . . .	1·95	·159	·0007	·0007	·00	0·510	0·07	0·21	0·28
Grasmere, Sept., 1868 .	2·92	·164	·035	·0007	·0	·550	·0	1·89	1·89
Rydal, Sept., 1868 . .	3·11	·178	·0301	·0014	·0	·483	·49	1·68	2·17
Windermere, Sept., 1868	4·05	·209	·0532	·0014	·0126	·693	1·12	1·68	2·80
Haweswater, May, 1867 .	2·49	·111	·0028	·0028	·0	·378	0·0	·91	·91
Ullswater, May, 1867 .	2·54	·047	·0000	·0021	·0035	·420	·35	·98	1·33
Thirlmere, May, 1867 .	1·86	·136	·0028	·0021	·0014	·364	0·0	·49	·49
Watendlath, May, 1867 .	2·13	·214	·0077	·0014	·0042	..	..	..	·70
Derwentwater, Sept., 1868	4·59	·153	·0301	·0007	..	·903	..	1·19	1·19
Bassenthwaite, Sept., 1868	3·25	·108	·0250	·0	·0	·903	·56	1·40	1·96
Buttermere, Sept., 1868 .	2·49	·089	·0280	·0028	·0	·623	·0	·70	·70
Crummock, Sept., 1868 .	2·84	·128	·0405	·0049	·0	·623	·0	·91	·91
Ennerdale, Sept., 1868 .	1·51	·029	·0119	·0	·0	·693	·0	·98	·98
Loch Katrine, Aug., 1870	1·68	·129	·0154	·0007	·0	·595	·0	·63	·63
Loch Lomond, July, 1870	2·40	·172	·017	·000	·000	0·840	0·07	2·00	2·07
Averages	2·65	·134	·02	·0014	·0014	·566	·17	1·03	1·3

Lake waters of the above character are valuable for steam purposes, for they do not yield the boiler incrustations or "fur" so characteristic of hard calcareous waters. They also are valuable for many factory purposes, and for all washing operations, inasmuch as their softness ensures absence of curd when they are used with soap. For drinking purposes these waters are perfectly wholesome, indeed their freedom from any suspicion of sewage contamination, with its consequent possible harmfulness, renders them desirable potable waters. The absence of carbonic acid, however, makes them flat on the palate, while the peaty matter often present gives them a faint bitterish taste, and a faint brownish-yellow unattractive colour. Fortunately, their free exposure to, and consequent admixture with air during their broken and tumbled travels in rough rocky beds as they flow towards towns, promotes the oxidation of the carbonaceous peaty matter to carbonic acid gas, thus at one and the same moment decreasing their colour and

flavour and increasing their aëration and palatable character. Thorough filtration through clean red gravel or sand accelerates such oxidation. On the small scale filtration through a cubic foot or two of coarse wood charcoal has a similar and excellent effect, not because any mechanical removal of matter takes place, such as goes on in the filtration of turbid water, but because the air and the dissolved peaty matter are brought together as in a furnace, undergo as true a combustion as they would in any ordinary furnace or fire-grate, and as truly yield carbonic acid gas, the latter giving the desired and usual sense of sharpness in the water as it passes over the palate. The same action goes on as the water passes through gravel, especially red ferruginous gravel, and, indeed, whenever and wherever the air and the peaty or other carbonaceous matters come together.

What has been stated respecting the composition and quality of these lake waters applies to all the upland surface waters which supply such lakes, and to the brooks or becks and rivers formed by the waters, whether they previously or afterwards expand into lakes or not. The waters mentioned are all supplied from the surfaces of what geologists term Metamorphic, Cambrian, Silurian, and Devonian rocks. Gathering grounds of similar geological character are not uncommon in Great Britain, and furnish some of our largest towns in the southern and northern counties of England, in Wales, and in Scotland with highly prized supplies of good water.

The upland surface waters from the igneous rocks of Cornwall, Devonshire, and Scotland, resemble those just mentioned, but are somewhat more peaty, and therefore require more prolonged contact with air before they become pleasantly potable.

The upland surface waters of the Yoredale and Millstone Grit and the non-calcareous portion of the Coal Measures may also be classed with the waters now under consideration, but contain about twice as much solids in solution; not more, however, than the still very small quantity

of five or six grains per gallon. They are very soft, the hardness being about three degrees per gallon. They contain much peaty matter. Many towns in Lancashire and Yorkshire are supplied with such waters.

All the foregoing upland and peaty waters are drawn from non-calcareous surfaces, that is to say, surfaces of rocks which do not contain chalk or other form of limestone soluble in water itself, or soluble by aid of the carbonic acid present in water. The calcareous or limestone uplands, however, such as those which yield the waters flowing into many Yorkshire, Northumberland and Durham streams, and which supply the basins of the Trent, Mersey, Ribble, Tyne, Wear, Tees, Forth, Tweed, Clyde, etc., also furnish peaty waters, which are collected in natural or artificial lakes and reservoirs and supplied, after due aëration, to towns. They contain twelve or fifteen grains per gallon of dissolved solids, have eight or ten degrees of hardness, and often are very peaty when first collected.

The peat which gives the character to all these lake waters, or waters similar to the waters of our British lakes, is a layer, from a few inches to several feet thick, of a more or less soft woody mass of the roots, twigs, etc., of many past generations of decayed grasses, mosses, heather and shrubs, etc. The colouring matter which it yields to the rain which falls on and flows from it is perfectly harmless. It contributes, however, an appearance and a flavour which are unpleasant in drinking water. Instinct, at all events in man, requires that water be colourless, clear and even sparkling, and either tasteless or, rather, that it shall have a so-called sharp "clean" effect on the palate. The only practicable process for the removal of the colour and flavour of peaty water is that of oxidation, or slow, but true, combustion, between the peaty matter and the oxygen dissolved in the water, as already described.

CHAPTER V.

NATURAL WATER-SUPPLIES—(CONTINUED).

5. *River water.*—The rain that falls on higher parts of the world flows by gravitation to the lower, wearing out channels for itself in its course. When the resulting streams are of a certain not very well-defined size, they are termed rivers. Clearly river water is, therefore, primarily rain water, and the characters of rain water have already been considered (p. 573). But it is, also, rain water of which part has penetrated surfaces on higher ground, has become disseminated through the subsoil, has dissolved from the enormous surfaces of the pores of the soil through which it has passed much of the soluble matters of the soil, as previously described (p. 576), has found an outlet on the hillsides of lower ground, and has then made its way into a river. Therefore river water is a mixture of upland surface water and spring water. Upland surface water is a good source of potable water, and spring water, as will be shown hereafter, is potable. But, further, river water receives the surface waters of lowlands. Now, in a highly-populated country like England, that amounts to its receiving not only all the water that has been pumped from, or, putting facts in another form, has fallen on those lowlands, but to its receiving that large proportion of the water which has been changed into more or less, often less, purified general drainage and sewage of highly cultivated and grazed lands, cattle sheds, stables, and inhabited houses. If such drainage has first passed through an adequate quantity of porous soil before joining a river, it has been subjected to that oxidation or slow combustion which has more than once been described, and which truly burns up all the impurities, reconverting the water called sewage or drainage into water called water, and which water, moreover, is as good and perhaps better in quality for drinking

purposes than it was before the fouling took place. Everybody well knows, however, that much of the household sewage water that gains access to rivers is not thus purified, hence the well-founded suspicion generally entertained against river water for drinking purposes. But, fortunately, the purification which sewage water is subjected to as it passes through porous ground it also is exposed to the moment it enters a river. Indeed, no sooner is water fouled than the air in the water commences to burn up the foul matter. This burning takes time; still, if a large surface of the water is exposed, so that as much air shall be absorbed as is used up in the destruction of the foul matter, and especially, therefore, if the river has an opportunity of getting well mixed with air in passing over weirs or in tumbling over a broken bed, or in passing through artificial gravel filters or sand filters, the foul matter is entirely burned. The elements of that matter are then converted into harmless and useful substances, namely, the element nitrogen into nitre (see p. 567) and the element carbon into the valuable aërating gas termed carbonic acid (p. 563). Whether or not any particular river used as a source of potable water is or is not in this purified condition at the place of intake of the water supply is a matter of evidence which the professional chemist alone can furnish. If the purifying power of the dissolved air is over-taxed, the proportion of dissolved oxygen in the water will be very small.

Gases in River Water.—The late Dr. William Allen Miller examined the water of the river Thames from the point of view just mentioned, in August, 1859. The water as it passed the more densely populated parts of London was at that time much contaminated, more so than now, and the difference in the proportion of dissolved oxygen at Greenwich, where the river was then at its worst, as compared with the proportion at Kingston, before the river entered London, where the water was fairly well aërated, or even at Erith, where the air again began to assert its mastery, was most marked.

INFLUENCE OF AIR AS AGAINST SEWAGE IN RIVER WATER.

Temp. of river 71° F.	Kingston.	Hammersmith.	Somerset House.	Greenwich.	Woolwich.	Erith.
Total quantity of gas in cubic in. per gallon.	14·67	Not determined.	17·49	19·77	17·50	20·64
Carbonic acid .	8·42	Not determined.	12·56	15·42	13·40	15·80
Oxygen . . .	2·07	1·16	0·43	0·07	0·07	0·52
Nitrogen . . .	4 18	4·24	4·50	4·28	4·03	4·32
Proportion of oxygen to nitrogen.	1 : 2	1 : 3·7	1 : 10·5	1 : 60	1 : 52	1 : 8·1

The dissolved solids in river water are those already stated to be present in variable proportions in all waters that have passed over or have penetrated the surface of the ground, namely: calcareous with a little associated magnesian matter, small in amount from non-calcareous gathering grounds, but forming the chief dissolved solids in limestone or chalk districts; a few grains per gallon of ordinary saline substances; and a little silica, etc.

The annexed table (page 587) shows the nature and amounts of solids in solution in waters of various rivers.

The proportion of organic (animal or vegetable) impurities in river water cannot be ascertained by direct weight. But the relative impurity of water can be determined with sufficient accuracy by noting the proportions of the elements (carbon and nitrogen) of that organic matter yielded under conditions which will hereafter be described (the "combustion" method); by noting the amount of ammonia which it will yield under certain circumstances (the "ammonia" method); or by noting the amount of oxygen required for completely oxidising or burning up the organic matter (the "oxygen" method). The second and third methods were those employed by Tidy in drawing up the statement on page 588 of the composition and quality of river water supplied to London by the five Thames companies in 1877

DISSOLVED SOLIDS OF RIVER WATERS.

(The figures show grains and decimal parts of a grain per gallon of 70,000 grains.)

RIVER . . .	CLYDE.	THAMES.	SEINE.	RHINE.	GARONNE.	RHONE.	LOIRE.	DOUBS.	NILE.
Analyst . . .	Penny.	Attfield.	Deville.	Deville.	Deville.	Deville.	Deville.	Deville.	.
Sulphate of potassium . . .	1·94	..	·350	..	·533	..	..	..	..
Chloride of potassium . . .	..	·69	..	..	..	..	..	..	..
Nitrate of potassium . . .	..	..	..	·266	..	·280	..	·287	·84
Sulphate of sodium	1·94	..	..	·946	·371	·519	·238	·357	..
Chloride of sodium	·54	1·11	·862	·140	·224	·119	·336	·161	·79
Nitrate of sodium	..	..	·659	..	..	·315	..	·273	..
Carbonate of sodium . . .	..	..	..	..	·455	..	1·023	..	·48
Sulphate of calcium. . . .	·26	3·60	1·886	1·030	..	..	..	..	1·32
Carbonate of calcium . . .	2·52	10·83	11·609	9·511	4·524	5·534	3·374	13·397	1·41
Silicate of calcium	..	..	..	..	..	..	..	..	3·87
Chloride of magnesium . .	·40	..	..	..	..	..	..	·035	..
Nitrate of magnesium . . .	..	·77	·364	..	..	..	..	..	..
Carbonate of magnesium . .	·72	1·20	·189	·350	·238	·343	·427	·161	1·15
Silica, with a little iron, alumina, phosphates, etc.	·87	·91	1·921	4·004	3·030	2·002	3·731	1·471	1·04
Total solids	9·19	19·11	17·840	16·247	9·375	9·112	9·129	16·142	10·90

COMPOSITION AND QUALITY OF THE METROPOLITAN WATER DURING THE YEAR 1877.

The quantities of the several constituents are calculated in grains per imperial gallon (70,000 grains).	Ammonia.		Nitrogen as Nitrates, &c.	Oxygen required to Oxidize Organic Matter, &c.	TOTAL SOLIDS.	Lime.	Magnesia.	Chlorine.	Sulphoric Anhydride.	Hardness on Clark's scale.	
	Saline.	Organic.								Before Boiling.	After Boiling.
	Grains.	Grains.	Grains	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Degrees.	Degrees.
Thames Water Companies.											
Grand Junction . .	0·000	0·007	0·129	0·068	19·85	8·150	0·816	0·89	1·568	12·9°	3·3°
West Middlesex .	0·000	0·007	0·132	0·064	18·81	7·973	0·364	0·90	1·450	13·0°	3·6°
Southwark and Vauxhall.	0·001	0·008	0·125	0·076	19·60	8·168	0·375	0·88	1·537	13·0°	3·5°
Chelsea	0·001	0·008	0·134	0·064	19·40	8·102	0·374	0·81	1·519	13·2°	3·1°
Lambeth . . .	0·000	0.008	0·156	0·067	20·27	8·437	0·446	0 94	1·694	13·8°	3·5°
Other Companies.											
Kent	0·000	0·002	0·351	0·005	28·06	11·248	0·718	1·45	3·328	19·1°	5·6°
New River . . .	0·000	0·006	0·134	0·040	19·02	8·246	0·386	0·88	0·166	13·3°	3·3°
East London . .	0·000	0·007	0·123	0·052	19·30	8·007	0·408	0·99	1·647	12·9°	3·4°

NOTE.—The amount of oxygen required to oxidize the organic matter, nitrates, &c., is determined by a standard solution of permanganate of potash acting for three hours, and in the case of the metropolitan waters the quantity of organic matter is about eight times the amount of oxygen required by it.

and the appended memoranda showing the extremes of the mean numbers given in the table. The so-called "New River" Company and the East London Company largely draw from the river Lea. The Kent water is a deep well water; its analysis will serve to give a complete view of

the character of the water supplied to London by the eight companies, but is included more especially to show the great superiority, as regards absence of animal and vegetable matter, of deep well water as compared with river waters. This point is demonstrated in the low figures in the two ammonia columns and the oxygen column. The total solids in the Kent water are greater in amount than in the river water by about eight grains per gallon of calcareous matter; this does not reduce the value of the water for drinking purposes, and it could be removed.

Grand Junction.—The total solid matter obtained by evaporation to dryness ranged from 17·00 grs. per gallon in July, to 22·90 grs. in March. The nitrogen as nitrates, etc., ranged from 0·090 gr. per gallon in August, September and October, to 0·195 gr. in March. The oxygen required to oxidize the organic and other matters ranged from 0·024 gr. per gallon in August, to 0·135 gr. in January.

West Middlesex.—The total solid matter ranged from 17·10 grs. per gallon in July, to 20·70 grs. in February. The nitrogen as nitrates, etc., ranged from 0·090 gr. per gallon in August and October, to 0·180 gr. in February. The oxygen required to oxidize the organic and other oxidizable matters ranged from 0·042 gr. per gallon in November, to 0·133 gr. in January.

Southwark and Vauxhall.—The total solid matter ranged from 16·70 grs. per gallon in August, to 20·80 grs. in April. The nitrogen as nitrates ranged from 0·097 gr. per gallon in October, to 0·198 gr. in March. The oxygen reguired to oxidize the organic matter, etc., ranged from 0·050 gr. per gallon in July to 0·138 gr. in January.

Chelsea.—The total solid matter ranged from 17·4 grs. per gallon in July, to 21·30 grs. in February. The nitrogen as nitrates, etc., ranged from 0·090 gr. per gallon in June and July, to 0·180 gr. in February. The oxygen required by the organic matter, etc., ranged from 0·021 gr. per gallon in August, to 0·120 gr. in January.

Lambeth.—The total solid matter ranged from 17·00 grs. per gallon in July, to 21·10 grs. in April. The nitrogen as nitrates, etc., ranged from 0·120 gr. per gallon in July and December, to 0·210 grs. in January and February. The oxygen required to oxidize the organic matter, etc., ranged from 0·047 gr. per gallon in October, to 0·094 gr. in January.

Kent.—The total solid matter ranged from 26·10 grs. per gallon in October, to 31·00 grs. in May. The nitrogen as nitrates, etc., ranged from 0·300 gr. per gallon in July, to 0·450 gr. in June. The oxygen required to oxidize the organic matter, etc., ranged from 0·001 gr. per gallon in February, to 0·015 gr. in July.

New River.—The total solid matter ranged from 16·10 grs. per

gallon in September, to 21·70 grs. in February. The nitrogen as nitrates, etc., ranged from 0·100 gr. per gallon in November, to 0·216 gr. in January. The oxygen required to oxidize the organic matter, etc., ranged from 0·017 gr. per gallon in September, to 0·094 gr. in January.

East London.—The total solid matter ranged from 14·90 grs. per gallon in December, to 22·70 grs. in January. The nitrogen as nitrates, etc., ranged from 0·090 gr. per gallon in June and July, to 0·180 gr. in February. The oxygen required to oxidize the organic matter, etc., ranged from 0·028 gr. per gallon in May, to 0·079 gr. in January.

The method of ascertaining the condition of river water, as regards animal and vegetable matter, by noting the proportion of two of the constituent elements (carbon and nitrogen) of such organic matter was employed by Frankland in drawing up data from which the following table is adapted. Here again the very low proportion of organic carbon and organic nitrogen and therefore of organic matter, that is, animal or vegetable matter, in the deep wells of the chalk (forming the Kent Company's water) as compared with the proportions in the waters of the rivers Lea or Thames, is particularly striking.

AVERAGE COMPOSITION OF LONDON WATER, 1868 TO 1877.

The figures show grains per gallon.	Total solid matter.	Organic carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as nitrates.	Total combined nitrogen.
From the Thames.	19·62	·141	·023	·0004	·147	·167
From the Lea .	19·47	·090	·016	·0003	·141	·157
From deep wells in the chalk.	28·80	·034	·008	·0001	·298	·306

The facts brought out in the foregoing tables and statements respecting Thames water may be regarded as illustrating general principles applicable to the waters of most rivers.

In addition to the mineral and organic solids dissolved,

river water may and often does contain solid matter in suspension. It consists of the insoluble part of the solid earthy matter mechanically dislodged from the gathering grounds of the waters, and the insoluble portion of whatever disintegrated animal and vegetable matter may gain access to those waters. It varies in nature and amount according to the nature of the ground whence the river is supplied with water, according to the violence of the rainfall and the rapidity of flow of the many streams and streamlets which together form the water of the river, and according to the extent to which the sewage of homesteads, villages, and more or less populous towns may be allowed to flow into the river. Its percentage proportion varies also as the water of the river may be high or low, and as the water may or may not be disturbed by river traffic.

6. *Sea Water.*—Sea water is not used as a beverage, hence it can receive but short notice in this Handbook. It has sometimes been administered as a medicine. As a source of distilled water for drinking purposes it has already been considered (see page 571). Used as a bath it is more stimulative than fresh water. The physical properties possessed by sea water in common with all water have already been described; some special properties have been mentioned on page 560.

Sea water contains in solution the gaseous, mineral, vegetable, and animal substances present in the waters of the rivers which flow into the sea. These remain behind when the surface water of the sea is evaporated, as it is continuously, by the heat of the sun, hence perhaps one of the causes of the present highly saline condition of the sea. On the other hand, sea-plants and fishes are always abstracting solid matter from the sea, and adding to submarine deposits. Probably the sea gains access or has gained access to soluble saline deposits such as those now occurring in the beds or mines of salt of our own country, and in the beds or mines containing many saline chemical substances now worked in Prussia. The suspended matters in the affluent rivers slowly settle in the sea, and, with the

shells and skeletons of animals, etc., no doubt slowly raise its floor.

The dissolved solids in sea water have been alluded to incidentally, in connection with the description of the solids met with in all waters (see pages 562 to 569). The following Table shows their names and proportions. The different rates of evaporation from the surface of the sea in tropical as compared with polar regions, and in comparatively quiet as compared with boisterous seas, and the influence of dilution by the fresh water of contiguous rivers, causes some variation in the composition of the water of different seas and of different portions of the same sea. The saline taste of sea water is due chiefly to the large proportion of common salt present, four and a half ounces per gallon, its bitterish character to the magnesian salts. Its greater buoyancy than fresh water is due to its greater density, one gallon weighing, as already stated, rather more than ten pounds and a quarter as against ten pounds in the case of pure water; in other words, in comparison with 1000 parts of pure water, the specific gravity is 1027½.

COMPOSITION OF SEA WATER.

(The figures show parts per thousand by weight. Multiplied by 72 they would show grains per gallon. Specific gravity 1027½.)

——	British Channel.	Mediterranean.
	(Schweitzer.)	(Usiglio.)
Water	963·745	962·345
Chloride of sodium	28·059	29·424
" of potassium	0·766	0·505
" of magnesium	3·666	3·219
Bromide of magnesium	0·029	0·556
Sulphate of magnesium	2·296	2·477
" of calcium	1·406	1·357
Carbonate of calcium	0·033	0·114
Iodine	traces	
Ammonia	traces	
Oxide of iron		0.003
Total.	1000·000	1000·000

Traces of silver, lead, copper, etc., have been detected in sea water.

CHAPTER VI.

NATURAL WATER-SUPPLIES—(CONTINUED).

7. *Spring Water.*—Just as water rushes or springs from any artificial fountain that is supplied through pipes from a reservoir at a higher level, no matter how far distant that higher reservoir may be; so water naturally springs from any crevice or porous spot in the ground that is supplied through underground channels with rain water which falls on a higher level, no matter how far distant that higher gathering ground may be. Such a *spring*, as it is termed, may be met with on the surface of the ground, or it may be met with in digging a pit at either a few or many feet from the surface. Not all water obtained by digging is spring water. Thus in digging the narrow pit called a well, we may reach the level of the lake, so to say, of underground water common to the whole of the vicinity, reach the level of the water in the now water-saturated gravel, or rock, or earth, and into which water-laden ground we push the excavation for a few feet in order to get a stock of clear water; in short, reach the plane of permanent saturation of the gravel, or rock, or ground beneath us. Such water is not fairly called spring water. Spring water, in fact, is water that springs, springs forth of itself; springs out obviously from the surface in some lane, or field, or moor, and forms the head of a streamlet; or, as we sink a well, springs out with the last strokes of the pickaxe and rushes into and rises into the shaft or boring. The physical cause of such a springing of water into a well may be demonstrated in the following manner. Push an empty winebottle into a bucket of water, nearly to the neck. Now, pass a poker down through the mouth of the bottle and knock a hole in the bottom. A miniature spring will

immediately rise in the bottle, and rise to the level of the outside water. That experiment illustrates what happens when water suddenly springs into the bore or shaft of a well, the impervious earth represented by the sides of the bottle being, perhaps, hundreds of yards, or even some miles broad, and sometimes very thick. The large basin-shaped masses of clay common in England, miles broad and wide, and hundreds of yards thick, form one variety of such water-impervious deposits. If the fields or other general surface-level of such deposits is below the level of the distant rain-gathering grounds, the springing water may not only rise into, but overflow a well, yielding what is termed an Artoisian or Artesian well, from the name of the French village of Artois, the site of one of the earliest of such recently made wells—although overflowing wells are not exclusively of modern date.

The words *spring water* express, therefore, not any particular quality of water, but only the mechanical conditions under which the water is obtained. If the self-same water were obtained by sinking a well into the distant rain-gathering grounds on the higher level until the plane of saturation were reached, the water there would not properly be termed spring water.

If a plane of saturation in a gathering ground rises by long-continued rain, any distant spring it affects will be augmented in volume; if a plane of saturation falls, through long-continued drought, its distant spring or springs will be diminished in volume. Any stream fed by such a spring will also be augmented or diminished in volume. After the excessively heavy rains we get at some four or five years or so of interval, the plane of saturation may rise so abnormally, as suddenly to give a spring where one does not usually exist, and this spring may feed a stream for some days or weeks, or, in fact, until the plane of saturation has slowly fallen to its normal height. Such springs or streams are known as *intermittent springs*, or brooks, or burns, or *bournes*. One occasionally rises beyond Caterham at about six miles from Croydon; another, the Hertfordshire Bourne,

appears at intervals of four to seven years in a meadow a little to the west of Haresfoot Park, and soon flows into the river Bulbourne, at the hamlet of Bourne End, about two miles south-east of Berkhampstead. From analyses of both of these springs, published by the author of this Handbook, it appears that the waters do not differ from the calcareous waters of the respective neighbourhoods. Intermittent streams do not appear and disappear, after the manner of a small surface stream, *pari passu* with rainfall. This is because the capillary attraction of soil for water is not overcome by gravitation, with production of a stream, until the soil is supersaturated with the water, and their adhesion for each other, mass with mass, brought to a minimum; the action of gravitation in respect of the mass of fluid is then at its maximum, and, once asserting itself, maintains a flow until the maximum amount of adhesion, mass of soil for mass of water, is again reached, and then the stream ceases. The action can be imitated by allowing a gentle spray of water to fall on a close sponge until a stream runs from the sponge; the stream will continue to run even though the spray is no longer falling; and when the stream ceases, if the spray be allowed to fall again, it does not immediately give a stream, the sponge first becomes supersaturated. In short, the limits of adhesion on the one hand and gravitation on the other are not abrupt, they overlap. The duration of flow of the intermittent stream is a measure of the overlapping. The phenomena of ebbing and flowing wells, like that near Settle, in Yorkshire, may be similarly explained. Indeed, similar influences are at work in the rise and fall of all streams.

With regard to the quality of spring water as a beverage, it is normally the same as the variety of water next to be considered, namely, well water. The gases and solids in solution in spring water are also, obviously, the same as those of the water of wells. From the mechanical conditions under which ordinary springs are supplied by nature, waters springing from the surface of the ground, including overflowing wells or Artesian springs, are perhaps

less likely to be contaminated than river water or the water of ordinary wells.

In the cases in which spring water is overcharged with animal or vegetable matter, the source of the mischief should, if possible, be detected and removed. Spring water organically not of best quality can be improved only by oxidation of its organic matter. Here, as usual, the aid of large gravel filters and sand filters is useful.

8. *Well Water.*—The source of the water in a well may be the rain which falls on the adjacent district, and which slowly percolates through the ground until it reaches the water-saturated plane, that is, the surface of the stock of water underlying the whole neighbourhood—just as rain falling on a large vat or other vessel filled with sand or gravel would sink, by soakage, until it reached the plane of saturation, that is, the level of water that had previously fallen on the surface and collected in the bottom of the vessel. In sinking wells we must expect to dig until we reach that plane. Residing on a hill we have to dig or bore many more feet if we live on the higher than if we live on the lower slopes of it, while at the foot we may reach water within a few feet of the surface. The plane of saturation is not itself level in the sense in which the water of an ordinary lake is level, for the water is held in the whole mass of the hill as in a sponge, by that capillary attraction or adhesion which has already been mentioned. The plane is in fact an inclined plane as regards any few yards of its surface, and, as regards its whole mass a sort of low cone, or hill within the hill, its sides on a much less sharp incline than the incline of the hill, whatever that may be. Then, too, the surface of the cone of water will scarcely be a perfectly regular surface, inasmuch as the material forming the hill will probably vary in porosity, and water is sucked up into narrow pores to a greater height than into wide pores, hence the height of water in contiguous wells may not be absolutely regular. The source of water in a well may, on the other hand, be a true spring, as described in the preceding

section. The stream of water yielding such a spring will pass more readily through loose than through close ground, hence in sinking wells into spring-laden strata we may have to go much deeper for water in some places than in others; obviously, also, we may, in boring, just miss a stream, perhaps finding another more deeply situated. Well water, whether drawn from the underground stock of water common to the district or from a true spring supplied from a distance, will, as already explained, be aërated by reason of the presence of the oxygen and nitrogen gases naturally dissolved from the air, and the carbonic acid gas partly dissolved from the air but more especially produced within the water itself by the true burning of dissolved vegetable or other carbonaceous matter by the contained and always renewed oxygen. The water will also contain the usual small amounts of various saline and calcareous substances dissolved from the soil through which the water has percolated.

Unfortunately, well water is also liable to contain a certain proportion, sometimes more, sometimes less, of the incompletely-purified drainage waters of the stable yard, cattle lair, pigsty, sheep pen, or refuse heap. Situated in the vicinity of a churchyard, chapelyard, or other place of interment, a well may contain the decaying animal matter of the dead; situated near a dwelling having old-fashioned sanitary arrangements, or one having modern but faulty pipe-sewerage systems, it may contain the decaying animal matter of the living. Even highly manured meadows or gardens may contribute impurities to water unless rain falling on the area has to percolate through some feet of porous air-laden subsoil before reaching the well. Shallow wells are most likely thus to be badly fouled. First, because their nearness to the source of contamination favours the minimum of dilution of the contaminating matter by the rainfall of the immediate vicinity. Secondly, because the oxidation, or true burning out of animal and vegetable matter in the water by the air in that water, depends on the extent of exposure of the water to the air in the pores of the soil through which the water

percolates, and that exposure is clearly less if the reservoir or well, or rather stock of water therein, is only a few feet than if it is many feet below the surface. Indeed, the only ordinary source of contamination of deep well water by surface impurities is the running of impure surface water down the sides of the well. The exposure of such impure water to the air whilst it trickles down the well will probably be quite insufficient to burn out the impurities; whereas the thorough admixture of the impure water with the air, that is, with the concentrated oxygen of the air, in the pores of the soil, during the percolation of the water through the soil to the level of the water in the deep well, will abundantly suffice to burn out all the impurities and convert the water into absolutely pure water—convert it by the method always adopted by nature—the method which transforms harmful carbonaceous matter into the useful, aërating carbonic acid gas, and harmful nitrogenous matter into useful nitre, the method by which nature enables us to use over and over and over again the constant stock of the water of the world.

The best means of preventing the pollution of deep well-water by impure surface water is to line the sides of the well with something impervious to water, extending the lining a foot above the ground and to such a distance down as may be deemed desirable. If the sides be iron tubes the joints will of course be flanged and be properly bolted together. If the sides be formed of brickwork the bricks should be set in cement and the front face be "floated," that is, plastered over, with the cement. If the well is already constructed and the bricks have been set with mortar, or, as more usual, without mortar, the inner face should be covered with at least an inch of good cement well prepared and well applied.

Deep well waters are among the best varieties of water for drinking purposes. Not only are they, usually, free from contamination, but are not excessively cold in winter and are deliciously cool in summer—unless, of course, they become warm in passing through great lengths of service

pipes before reaching the consumer. A private deep well water supply to a house is a great luxury.

Whether well water is or is not contaminated can sometimes be ascertained by the unaided nostrils. Three parts fill a common water bottle with the water, close the bottle with the palm of the hand and well shake, only removing the hand when the bottle is so close to the face that one can instantly insert the nose well within the wide aperture of the neck. If the water has a bad smell it is not fit to drink. If nothing unpleasant is detected, tightly cork up another quantity of the water in the bottle, set it aside in any warm place at about the temperature of one's body for a day or so and repeat the shaking, etc. If it then has a bad smell its use for drinking purposes should be avoided. Amateur testing can scarcely go farther. For thorough analysis, and for proper advice, the householder must seek the aid of the professional chemist.

In the following table are given analyses, by the Author, of waters that, in his opinion, are typical well waters. The two varieties of ammonia were eliminated by the "ammonia" method of Wanklyn and Chapman. The other substances named were determined by the ordinary methods.

A satisfactory opinion on the fitness of a sample of well water for drinking purposes can only be formed after some such an analysis as those of which the data are given in the table (see page 600). The extent to which a sample of water will absorb oxygen may be indicated in an added sentence. The absence of lead in well water drawn through lead pipes or stored in lead cisterns should be ascertained. The total amount of carbon and nitrogen yielded by the water residue is given by some analysts.

It is difficult to remedy the pollution of shallow wells. If the source or sources of pollution can be detected and removed the water may in time recover its normal quality, whatever that may be. The remedy for pollution in the case of deep wells, if due to the surface impurities, is the same as that recommended for the prevention of access of surface impurities, namely, to shut out all surface water by

DISSOLVED SOLIDS IN TYPICAL WELL WATERS.

(The figures show grains and decimal parts of a grain of the respective substances in one gallon of the water.)

—	Good. From siliceous soil.	Good. From chalky soil.	Bad. From siliceous soil.	Bad. From chalky soil.	Bad. From blue clay.	Bad. Near church yard.	Good. From a deep well.
Total solid matter, dried at 212° F.	12·	25·	16·	51·	134·	45·	26·
Ammoniacal matter, yielding 10 per cent. of nitrogen	0·01	0·02	0·03	0·03	0·19	0·01	0·01
Equal to ammonia per million	0·02 (nearly.)	0·04 (nearly.)	0·05	0·05	0·33	0·02 (nearly.)	0·02 (nearly.)
Albumenoid organic matter, yielding 10 per cent. of nitrogen . . .	0·03	0·04	0·09	0·09	0·06	0·24	0·01
Equal to ammonia per million	0·05	0·07	0·16	0·15	0·10	0·41	0 02
Nitrites	none.	none.	none.	trace.	none.	trace.	none.
Nitrates—containing 17 per cent. of nitrogen	0·47	0·6	1·8	5·9	0·47	11·8	1·7
Equal to grains of nitrogen per gallon	0·08	0·1	0·31	1·0	0·08	2·0	0·3
Chlorides—containing 60 per cent. of chlorine	2·0	3·5	10·3	16·8	36·7	6·7	2·7
Equal to grains of chlorine per gallon	1·2	2·1	6·2	10·1	22·	4·0	1·6
Hardness—reckoned as chalk-grains or "degrees";							
Removed by ebullition	2·	14·	2·	13·	11·	16·	16·
Unaffected by ebullition	3.	5·	5·	10·	4·	11·	5.
Total hardness	5·	19·	7·	23·	15	27·	21·

cementing the inner face of the well to a considerable depth. Some time must then be given for the water to recover its original condition, the water in the well being occasionally reduced as far as possible by continuous pumping for several hours, or the well may be pumped dry two or three times if that be practicable.

The use of polluted well water, or polluted water of any kind, for drinking purposes, should, of course, be avoided; for it may at any time spread fever, anyhow it will probably debilitate those who drink it, and, to say the least, its associations are loathsome. The thorough boiling of such water will greatly reduce its liability to do harm, but this expedient is not altogether satisfactory, and should only be resorted to until a better supply of water can be obtained.

9. *Mineral Waters.*—These will be described in the next chapter.

SECTION II.

MINERAL WATERS AND AËRATED BEVERAGES.

CHAPTER I.

MINERAL WATERS.

MOST of the true mineral waters are not beverages in the ordinary sense of the word. They are medicines; mild as a rule, and, therefore, taken in doses which are large as compared with the more usual doses of medicinal articles; nevertheless, they are true medicines, and, hence, any detailed notice of them would be out of place in this Handbook. Full analyses of a very large number will be found in Squire's Companion to the British Pharmacopœia. The accompanying tables are taken from that work.

CLASSIFICATION OF THE MINERAL WATERS.

Comparatively Normal.

Bristol.
Buxton.
Clifton.
Gastein, 118°.
Malvern.
Schlangenbad, 50°.
Wildbad, 98°.
Winfred.

Alkaline and Gaseous.

Chateldon.
Condillac.
Contrexville, 53°.
Dorfles.
Ems, 85° to 117°.
Fachingen.
Gieshübler.
Neuenahr, 70° to 102°.
Vals.
Vichy.
Wildungen, 96°.

Saline.

Harrogate.
Homburg, 50° to 52°.
Kissengen, 49° to 51°.
Minerva.

Bitter Saline.

Birmenstorff.
Cheltenham.
Epsom.
Friedrichshall.
Hunyadi Janos.
Hungarian (Royal).
Kingswood.

CLASSIFICATION OF THE MINERAL WATERS—*continued.*

Leamington.
Marienbad.
Pullna.
Seidlitz.

Saline containing Bromine and Iodine.

Achselmannstein, 61°.
Adelheidsquelle, 50°.
Arnstadt.
Carlsbad, 119·3° (Mark-brunnen).
Cheltenham.
Durkheim.
Ischl.
Kœnigsdorff-Jastrzemb.
Kissingen, 49° to 51°.
Krankenheil.
Kreuznach, 54·5°.
Luhatschowitz, 48·6°.
Megentheim.
Mondorf, 77°.
Reichenhall.
Tarasp, 37°.
Wiesbaden, 160°.
Woodhall.

Saline containing Lithia.

Baden-Baden.
Carlsbad, 119° (Mark-brunnen).
Franzensbad, 45°.
Kissingen, 47° to 51°.
Weilbach, 54°.

COOL, AND THERMAL, UNDER 98° F.

Sulphurous.

Baden, Austria, 92°.
Berka.
Bonnes, 91·5°.
Challes.
Eilsen, 59°.
Enghien.
Harrogate.
Krankenheil.
Labassère, 54°, 57.
Landeck, 81° to 83°.
Meinburg, 61°.
Nenndorf, 52°.
Schinznach, 96°.
Strathpeffer.

Chalybeate and Gaseous.

Alet.
Alexandersbad.
Alexisbad.
Altwasser.
Auteuil.
Berka.
Bocklet, 50°.
Bossang.
Charlottenbrunn.
Driburg, 51°.
Harrogate.
Kösen, 65°.
Kronthal, 61°.
Lippspringe, 70°.
Marienbad.
Meinburg.
Orezza.
Pougues.
Pyrmont.
Recoaro.
Rippoldsau.
Saint Maurice, 42°.
Schwalbach, 46° to 51°.
Soden, 68° to 74°.
Spa, 52°.

HOT SPRINGS.

Wildbad, 98°.
Pfaffers, 100°.
Neuenahr, 102°.
Vichy, 106°.
Lippik, 111°.
Lucca, 116°.
Ems, 117°.
Bath, 118° to 120°.
Gastein, 218°.
Teplitz, 120°.
Leuk, 124°.
Cauterets, 131°.
Aix-la-Chapelle, 131°.
Verney, 137°.

HOT SPRINGS—*continued.*

Ofen, 141°.
Baden-Baden, 155°.
Ischia, 158°.
Plombières, 159°.
Wiesbaden, 160°.
Carlsbad, 162°.
Borcette, 171°.

Sulphurous.

Baréges, 111°.
Aix-les-Bains, 116°.
Aix-la-Chapelle, 131°.
Cauterets, 131°.
Borcette, 140°.
Bagniéres de Luchon, 154°.

The following is a list of mineral waters drunk at table, with their source, number of grains of solids in solution, and the names of the chief compounds. As a class these table waters occupy an intermediate position in relation to water or plain aërated water on the one hand and the more active mineral waters on the other. Their carbonic aëration renders them exhilarating, while any mineral carbonates present give them a desirable mildly antacid medicinal character. Persons regarding them as beverages should remember that it is the water itself in them that makes them beverages, and that their dissolved solids do not, like those of "tea," include a stimulating principle, nor, like those of milk, a nourishing principle, but are composed of useful yet distinctly medicinal substances.

MINERAL WATERS DRUNK AT TABLE.

The imperial pint of the water (20 oz.) contains of saline matter as follows:

Apollinaris	(Rhenish Prussia)	22	grains	chiefly carbonate of sodium.
Bellthal	(Rhenish Prussia)	30	"	carbonates of calcium, magnesium, and sodium.
Bilin	(Bohemia)	43	"	chiefly carbonate of sodium.
Birresborn	(Rhenish Prussia)	42	"	carbonate of sodium and chloride of sodium.
Condillac	(France, Drôme,)	11	"	chiefly carbonate of calcium.
Evian	(Switzerland)			
Gerolstein	(Rhenish Prussia)	16	"	carbonates of calcium, magnesium, and sodium.
Gieshübler	(Bohemia)	12	"	chiefly carbonate of sodium.

MINERAL WATERS DRUNK AT TABLE—*continued.*

Harzer	(Germany)	11 grains	carbonates of calcium and sodium, and chloride of sodium.
Roisdorf	(Rhenish Prussia)	34 "	chloride of sodium, carbonates of sodium, calcium, and magnesium.
Rosbach	(Homburg)	15 "	do. do.
St. Galmier	(Badoit, France,)	30 "	do. do.
Seltzer	(Nassau)	38 "	chloride of sodium, and carbonate of sodium.
Sulis	(Bath, Somerset,)	20 "	sulphates of calcium and sodium, chloride of magnesium and sodium.
Taunus	(Frankfort)	30 "	carbonate of calcium and chlorides of potassium and sodium.
Wilhelmsquelle	(Frankfort)	21 "	chloride of sodium and carbonate of calcium.

To the student of water, mineral springs present many points of interest. Various speculations have been offered as to the source of the heat of those which burst forth in continuous volumes year after year at an elevated temperature, in some cases approaching the boiling point. The source of the large quantities of saline substances in most of the mineral waters has been less questionable since the discovery of mines of such materials in Prussia and elsewhere. These mines show that beneath the surface of our earth there are in certain spots extensive deposits of the less common soluble saline substances such as are met with in mineral waters; an underground spring or stream of water soaking through the soil near such deposits would certainly become more or less impregnated with the salts. Some of the ingredients are doubtless the result of the reaction of certain of the more normal compounds on each other. One of the most striking facts in connection with these waters is that the relative proportions of the many substances present should be maintained from year to year,

with scarcely any variation worth mentioning. The composition of the water of the Montpellier Strong Sulphur Well at Harrogate may be referred to in illustration of this character. This water has been analysed four times within thirty-five years without any marked change being observed, as shown in the following table, in which Thorpe has so arranged the results by the four analysts as to allow of a comparison being made in respect of each of the metallic and acidulous radicals of the various compounds, contained in 1000 parts of the water.

Analyst . . . . Date	West. 1845.	Hofmann. 1854.	Attfield. 1879.	Wilson and Ingle. 1880.
Ammonium (NH_4)	..	trace.	0·00474	
Barium . .	..	..	0·00276	0·08774
Bromine . .	..	marked trace.	trace.	0·01114
Calcium . .	0·4372	0.4547	0·45657	0·50536
Chlorine . .	8·8730	8·0637	8·49064	8·65580
Iodine . . .	..	marked trace.	trace.	0·000053
Iron . . .	..	trace.	0·00283	0·00205
Magnesium . .	0·1843	0·1964	0·20705	0·21015
Nitrates (NO_3)	..	..	0·00028	
Potassium . .	..	0·0428	0·03559	0·04145
Sodium . .	4·9792	4·5865	4·72167	4·81577
Silica . . .	..	0·0261	0·05045	0·03058
Strontium. . .	..	..	0·02554	0·00174
Sulphur (as H_2S)	0·0952	0·11608	0·08405	0·10018
Sulphates (SO_4)	..	0·0059	0·00635	
Total residue .	..	13·5881	14·09752	14·40095
Specific gravity .	..	1·01045	1·0109	1·011152

The bibliography of mineral waters is very fully given in Waring's *Bibliotheca Therapeutica*, vol. 2, pp. 775–805 One of the earliest works was published by W. Turner in 1562, 'A Booke of the Nature and Properties as well of the Bathes in England as of the Bathes in Italy and Germany.' One of the most elaborate is by M. Gairdner, an 'Essay on the Nature, History, Origin, and Medicinal Effects of Mineral and Thermal Springs.' Edinburgh, 1832.

CHAPTER II.

ARTIFICIALLY AËRATED WATERS.

ALL water in nature contains a little *aër* or air, or gas, in solution, usually oxygen gas, nitrogen gas, and carbonic acid gas. These are the gases of our atmosphere, and water absorbs them from the atmosphere. (See p. 563). Artificially, water cannot be made to absorb much oxygen or nitrogen, these gases being very slightly soluble in water. But carbonic acid gas is fairly soluble. Water can, under certain circumstances, take up quite its own bulk of carbonic acid gas; for example, half a pint of water can hold in solution half a pint of carbonic acid gas. A pint of carbonic acid gas can readily by pressure be squeezed to half a pint, but half a pint of water will still dissolve this half pint of condensed carbonic acid. Water itself is almost incompressible (see p. 551), gases are easily compressed to almost any extent, but if the water and the gas are both under the same pressure, the half pint of water will still dissolve half a pint of compressed gas, no matter how many original half pints the compressed half pint of gas represents. This property of water in respect of carbonic acid gas applies to all fluids and all gases. Whatever the weight and volume of a gas dissolved by a liquid at ordinary atmospheric pressure, that weight is doubled by double pressure, the two original volumes of gas thereby being reduced to one, trebled at treble pressure, the three original volumes of gas being reduced to one, quadrupled at quadruple pressure, the four original volumes of gas being reduced to one, and so on. This is a general law regarding the solubility of gases in liquids under given temperatures. It is known as Henry and Dalton's law, from the names of the philosophers who first unveiled the law. An average bottle of "aërated water" contains about four times the

weight of carbonic acid which can exist in it without artificial pressure, so that on removing its cork three times its bulk escapes, its own bulk remaining dissolved.

The only practically available *aër* or gas for aërating beverages is carbonic acid. Bottled beer and sparkling wine are aërated by internal production of carbonic acid during fermentation. Water is artificially aërated by direct absorption of carbonic acid gas previously prepared and stored for the purpose. A few natural mineral waters which escape from the ground in an effervescing condition may have absorbed carbonic acid by direct contact with the free gas, or their dissolved carbonates may have yielded carbonic acid by the water coming into contact with strong acid vapours or fluids.

The physical and chemical characters, including composition of carbonic acid gas and the various carbonates, can only be thoroughly studied in a chemical laboratory under the guidance of experts. The gas is produced whenever the carbon in the fuel of our flames and fires, including the fire which is always burning within our bodies and keeping us warm—whenever carbon unites chemically with the maximum proportion of oxygen of the air. Carbonic acid is nearly half as heavy again as air ; a room twelve feet broad, twelve wide and twelve high contains about 132 pounds weight of air, but would hold about 200 pounds of carbonic acid gas. But the gas does not, therefore, fall from our chimneys and mouths to the ground, collecting there as a layer, and suffocating us all—for carbonic acid gas, in quantity is irrespirable. The fact is that although subject to the law of gravitation, it is also subject to the law of diffusion, by virtue of which a heavy gas passes up into a light gas and a light gas descends into a heavy gas. The rate of diffusion is also subject to law, namely, it is in inverse proportion to the square root of the specific gravity.

To collect, and use for water-aëration, the carbonic acid gas produced on burning the carbon in the fuel of our fires and flames, would be impracticable ; it is conveniently and quite cheaply obtained from the chemical substances termed

carbonates. Chalk is a carbonate. One hundred pounds of chalk heated in a strong fire (a lime kiln) yield fifty-six pounds of lime, and forty-four pounds of carbonic acid gas. Hence to fill a room twelve feet broad, twelve wide, and twelve high, that is, 200 pounds of carbonic acid gas, would require about 455 lbs. of chalk, or, say, five hundredweights of ordinary damp chalk as dug from a chalk-pit. The makers of artifically aërated waters do not produce carbonic acid gas from chalk by heat, but by adding strong acid, sulphuric acid, generally called by its old name "oil of vitriol," to the chalk. The gas is then yielded in a manageable stream which is purified by so arranging the conveying tubes that the gas shall bubble through water. It is afterwards stored in large cylinders similar to those seen in the vicinity of coal-gas factories.

Aërated Water.—Ordinary water of good quality is violently shaken with carbonic acid gas in appropriate vessels under great pressure. The product is passed into the familiar "soda-water" bottles, or other equally strong bottles, instantly corked or otherwise closed, and the cork or other stopper immediately and securely fastened to the bottle. The whole process is very rapidly performed by the aid of extremely ingenious machinery which produces many thousands of bottles per day with a minimum of manual labour. Aërated water is often, perhaps generally, termed by the public soda-water. This arises from the fact that the original effervescing fluid was a distinctly medicinal article containing "soda," or rather carbonate of sodium. But the public demand for the fluid, which rapidly increased, was accompanied by a decreased demand for the soda present in it. The demand in fact was for a beverage and not for a medicinal article. The public have been supplied with the article they desired, but are very slowly induced to alter the old and now misleading name. The result is that manufacturers have sometimes been twitted by unthinking persons with being guilty of what is akin to fraud, while the fault, such as it is, has rested entirely with the public. True soda-water, containing fifteen grains of

bicarbonate of sodium in the half-pint, can be had of the qualified druggist; but where purchasers ask for one bottle of "soda-water," meaning soda-water, they ask for a thousand bottles of "soda-water," meaning plain aërated water, and if supplied with true soda-water, would return it as "bad," "nasty," "soapy," etc. This is no question of price. If true soda-water were required in the quantities in which the so-called soda-water is demanded, it could be supplied at the same price.

Aërated water is a beverage. It quenches thirst by virtue of its water, it soothes the stomach, and it indirectly exhilarates by virtue of its carbonic acid.

Soda and Potash Waters.—The true artificially aërated alkaline waters known by these names are, strictly speaking, medicinal articles of the antacid type. They are not beverages, if by that word is meant pleasant thirst-quenching drinks. Medicinal soda-water has just been described. Medicinal potash water also contains fifteen grains of bicarbonate of potassium in the half-pint. Both are directed to be of this strength in the official medicine-book of our country, the British Pharmacopæia. *Lithia water* contains five grains of carbonate of lithium in the half-pint. It is a medicine.

Compounds of iron, sulphur, and many other medicinal substances are occasionally administered in the form of artificially aërated waters.

Thirst-quenching aërated drinks, appropriately sweetened and flavoured, and containing small quantities of tonics, stomachics, phosphorics, or other classes of substances, have been introduced to public notice under such names as ferrade, zoedone, hedozone, phosphade, etc.

Lemonade.—Aërated lemonade is aërated water (page 609), passed into bottles containing a little syrup of lemon. The familiar and refreshing "still" lemonade of our households is not an aërated beverage, but may be noticed shortly here. It is made by adding juice of lemons and a litttle lemon-peel to sweetened water. It is the old King's Cup. Prepared, not with lemon juice, but

with the natural commercial acid of lemon juice, namely, citric acid, a brighter and clearer lemonade results—lemonade without the mucilage and useless pulpy particles of the juice. The use of commercial oil of lemon-peel instead of the peel is not attended with any similar advantage, for soon after the lemon oil is extracted from the vesicles of the peel, it loses some of its finer and more delicate flavour and aroma. What has been stated respecting lemonade applies to *orangeade*. Similar drinks may be prepared with the juices of raspberries, strawberries, apples and other fruits, citric acid being added when necessary, or, in the absence of citric acid, tartaric acid. The palate is the best guide to proportions. The old Persian *sherbet* was a fruit beverage of this kind.

Ginger Beer.—Aërated ginger beer is aërated water (page 609), passed into bottles containing a little appropriate syrup of ginger. Ginger ale contains, in addition, a little harmless colouring matter to simulate that of ale. Gingerade is a similar beverage. Occasionally a little mucilaginous or similar matter is added to give persistence of froth, there being some demand for that good "head" to the fluid said to be characteristic of the old-fashioned ginger beer. The latter is made from a properly sweetened and slightly acidified infusion of ginger, to which yeast is added. After appropriate manipulation, as for wine or beer, it is bottled. Carbonic acid generated within the fluid gives, after a few days or weeks, an aërated drink ; but this variety of ginger beer is also an alcoholic drink, for the fermentation which is set up by the yeast in a part of the sugar gives rise to a little alcohol as well as to carbonic acid.

Seltzer Water.—With the view of producing *extemporaneous mineral waters*, particularly those drunk at table, attempts have been made to exactly imitate the natural mineral waters by bringing together the different compounds named in analyses of such waters, in the stated proportions, dissolving them in the proper quantity of distilled water, and artificially aërating the product. Hitherto the public

has not given very strong support to these endeavours. But aërated water containing the two or three substances present in largest proportion in the "Seltzer water," or water of the Seltzer spring of Nassau, namely, bicarbonate of sodium, chloride of sodium, and calcareous compounds, is manufactured in enormous quantities as an after-dinner table-water. It is saline and antacid. It is sold at a cheap rate, with no pretence that it is the natural seltzer water; indeed the vendors of it usually supply the natural water also. It meets a demand for a semi-medicinal yet thirst-quenching aërated beverage. It is sometimes termed Saline Water, but is more generally called Seltzer Water, the original mineral water being termed *Natural* Seltzer Water.

SECTION III.

WATER-PURIFICATION AND ANALYSIS.

Purification of Water.—The modes of purifying water are either mechanical or chemical, according as the impurities are in suspension or in solution.

From suspended impurities, causing more or less turbidity, water is purified by subsidence and by filtration. On the large scale subsidence is carried on in reservoirs, on the small scale in water-butts, tanks, and cisterns. The process is, necessarily, slow. The deposited matter should periodically be removed. In semi-barbarous countries muddy water is sometimes fined or cleared by the addition of the mucilaginous pulp of certain fruits, after the manner in which Europeans clarify wine, coffee, etc., by the addition of white of egg or of isinglass. The glairy matter slowly coagulates, enclosing the suspended matters as in a net, leaving the fluid clear.

Filtration is conducted on the largest scale through gravel and sand, through spongy iron also. On the small scale through spongy iron, carbide of iron, charcoal, sponge, cloth, paper, some other materials being occasionally employed. The chief objection to filtration is the liability of a portion of the impurities to decompose, and to increase instead of decrease the impurity of water subsequently passed through the filters. To prevent such an unfortunate result the filters must be duly cleansed. Large filters are of necessity kept in order; household filters are, to say the least, liable to be neglected.

Impurities in solution are of a mineral nature or they are organic, that is, of an animal or vegetable character.

From the point of view of steam users, manufacturers, and persons using soap, dissolved carbonate of calcium (chalk, or less correctly "the lime,") in water is an impurity. It can be removed by adding to the water a proper proportion of slaked lime, giving time for subsidence, and drawing off the clear water. The process is adopted by companies at Bushey near Watford (see p. 548), Canterbury, Caterham, and Chiltern, and in a few large establishments. For small households the method is at present too troublesome. The explanation of the process is as follows. Chalk, a compound of carbonic acid and lime, is practically insoluble in pure water. But it is soluble in all ordinary water, because the water contains additional carbonic acid. On adding lime it unites chemically with this carbonic acid and forms a little more chalk. The chalk formed and the chalk originally present having now no free carbonic acid to hold it in solution, is thrown out of solution and is slowly deposited. The process is known as the Clark process; it was first introduced by the late Dr. Clark of Aberdeen. In the "Porter-Clark" process, and in the "Atkins" system, the separated chalk is at once filtered out through cloths.

The only practicable method of removing other mineral substances from water is by distillation (see page 569).

To remove organic matter from solution in water oxidation by the oxygen of the air is the only practicable process. This action goes on directly but slowly in lakes or other sheets of water exposed to air. It goes on more rapidly when air and water are well mixed, as in the tumbling of water down weirs, cataracts and waterfalls, and in the rushing of rivers along rocky beds. It goes on most satisfactorily when water percolates through porous and therefore air-laden soil on its way to springs, wells, etc.; hence, by the way, the value of deep wells, the water of which is fifty to a hundred feet below the surface of the ground, for the rain water supplying such wells even if fouled at the surface becomes converted into pure water before it reaches or becomes part of the water in the well.

Filters, fortunately, act chemically as well as mechanic-

ally, in so far as they bring the organic impurities in the water and the oxygen of the air into closer contact and, therefore, under good conditions for that chemical attack on each other which results in the entire alteration of both into a minute quantity of harmless nitre added to the water and a small quantity of carbonic acid which gives desired aëration to the water. Such a filter, therefore, is an actual fire-grate. A pound of animal or vegetable matter burned in a fire-grate is converted by the air drawn into the fire into several pounds of carbonic acid gas, etc., which pass up the chimney. A pound of animal or vegetable matter contained in water passing through a filter is burned in that filter by the air dissolved in the water into several pounds of carbonic acid, etc., which pass into the water. It is interesting to add that just as much heat is given out in the one operation as in the other. In the fire-grate the burning is rapid and concentrated and the warmth can be felt; in the filter it is slow and diffused over such a vast mass of water that the best thermometer is not delicate enough to detect it.

Analysis of Water.—The analysis of water, or, rather, of the substances which may be present in the water, involves a series of operations of so special and technical a character that no useful purpose would be served by describing them in a Handbook intended solely for the general public. To ascertain the nature and amount of each of the dissolved solids will occupy the whole time of an expert chemist for several days. Such a complete analysis is, however, only required by certain manufacturers, brewers, water companies and owners of mineral springs. The ordinary mineral substances in drinking waters not being impurities, the chemist analysing water for potability does not take notice of them unless they are present in abnormal proportions. It is to the organic, that is, animal or vegetable matter present, that he devotes his attention. Even an analysis from this point of view occupies several hours. He ascertains the total amount of "dissolved solids" present; tests for the substances termed "nitrites," finds out how much nitre is in

the water, or "nitrates;" "chlorides" also; detects the character and amount of "hardness," and, either by the "combustion" mode, "ammonia" method, or "oxygen" process, already alluded to, makes an estimate of the harmfulness or harmlessness of the organic matter in the water. All this is done on the assumption that the sample of water is a fair sample, carefully collected in a cleansed and well rinsed bottle closed by a clean and well rinsed cork or stopper. (A stoppered "Winchester Quart," obtainable of any druggist, is perhaps the best vessel for collecting a sample of water for analysis). With the instructions to analyse should be sent a statement as to whether the water is from a well, river, etc.; if a well, whether it is known to be a shallow or a deep well; and what is the general nature, if known, of the soil, sub-soil, and general surroundings of the well, etc. From all these chemical and general data the professional chemist will be able to form an opinion respecting the quality of the water for drinking purposes—an opinion that will be among the best founded and most trustworthy of those sought from professional men by the public. Typical analyses of lake waters, river waters, and well waters, will be found on pages 580, 581, 587, and 600.

Hardness.—The extent of hardness of water, caused by the calcareous and magnesian substances present, is ascertained by finding how much soap is used up in obtaining the maximum quantity of the familiar curdiness. The amount of curd produced by one grain of chalk is termed one "degree" of hardness. A water is not unpleasantly hard if one gallon has not more than ten degrees of hardness. A certain portion of soap must destroy or decompose, and itself be destroyed or be decomposed by, the hardening substances, and thus be wasted, before the bulk of the soap can aid the water to dissolve or remove dirt from the skin, linen, or other unclean surfaces or fabrics. "Temporary" hardness, due chiefly to chalk, is that removable by prolonged ebullition or by lime (p. 614); "permanent" hardness, due chiefly to gypsum, is that not so removable. "Soda" neutralises both kinds.

SECTION IV.

OTHER UNFERMENTED BEVERAGES.

CHAPTER I.

TEA.

TO the great majority of people a cup of tea is the most popular of beverages. It both soothes and stimulates, it is grateful to the senses, its associations are pleasant, and it is easily prepared. It is an infusion, in the hottest water, of the manipulated and dried leaves of a plant, the *Thea sinensis*.

The history of tea is obscure. It is said to have been introduced to China from India in the sixth century A.D., and to Japan from China in the eighth. The Chinese appear to have been the first to recognise the properties of tea. Indeed, the Indian tea now so largely imported into Great Britain from Assam is the outcome of an industry started by our Government so lately as forty years ago by the help of seed imported from China. Some support to the claim of Eastern India as the natural, if not the commercial, home of tea is afforded by the plant itself, the native Indian plant growing to the dimensions of a tree, while that of China is a bush, and trees flourish best in their own native air and soil. The great consumers of tea are the English, the Americans, the Dutch and the Russians.

The chief varieties of the plant, for their title to the dignity of species is questioned, are the *Thea Bohea* and *Thea viridis* of China and the *Thea Assamica* which furnishes the Indian tea. The usual appearance of the mature plant is that of a shrub of strong growth some five or six feet high having leaves suggestive of those of the common bay, and having blossoms suggestive of those of the white flowering blackberry. The character of the plant is, of

course, much influenced by soil, cultivation, and climate. The conversion of the fresh leaves into the dried leaves of trade resembles in principle the conversion of grass into hay. That is to say, like grass, tea must be exposed to natural or artificial heat until its life ceases; like grass, tea must be fermented to develop fragrance and flavour; and, like grass, it must be dried. Further, the tea-leaf must be rolled into a little ball in order that its qualities, as judged by the nose and palate, may be the better preserved, and that it may be packed more closely. A gathering takes place in March or April, a second in May or June, and generally a third in August. The first picking is the best. Some of the quality depends on whether the bursting downy buds (Pekoe or Pak-ho means "white down") only are collected, or the young leaves, or the more fully grown leaves, and whether the leaves are gathered without or with their stalks. Davis, in his 'China,' vol. ii. p. 351, says: "black tea contains much of the woody fibre, while the green is the fleshy part of the leaf itself." The quality of tea is very largely dependent on the care and skill with which it is manipulated in the gathering, fermenting, drying, rolling, and packing processes; for, as might be expected, the best tea becomes inferior by bad harvesting. Occasionally tea is pressed into rectangular blocks after softening the leaves by steam, and is dried and exported in that form more especially to the Tibetan and Mongolian markets. It is known as *brick tea*. It is usually of inferior quality, containing much stalks and tea dust.

Tea was introduced into England more than two hundred years ago. Samuel Pepys, F.R.S., in his Diary, on the 28th June, 1667, says "Home, and there find my wife making of tea; a drink which Mr. Pelling, the Potticary, tells her is good for her cold and defluxions." About seven years before, namely, on the 25th September, 1660, he writes, "I did send for a cup of tee (a China drink), of which I never had drank before." A footnote to a recent edition of the Diary includes the following two quotations; "Coffee, chocolate, and a kind of drink called *tee*, sold in

almost every street in 1659." Rugge's *Diurnal.* "Tea was then so scarce in England, that the infusion of it in water was taxed by the gallon, in common with chocolate and sherbet. Two pounds and two ounces were in the same year formally presented to the King by the East India Company, as a most valuable oblation." *Quarterly Review,* vol. viii. p. 141. The late Daniel Hanbury, F.R.S., a few years ago drew attention to the following advertisement in a copy of the *Mercurius Politicus,* No. 435, September 23rd to 30th, 1658, preserved in the British Museum. "That Excellent, and by all Physitians approved, *China* Drink, called by the Chineans, Tcha, by other nations *Tay alias Tee,* is sold at the *Sultaness-head,* a *Cophee-house* in *Sweetings* Rents, by the Royal Exchange, *London.*" Tea was known to the English East India Company quite early in the century, but it was probably first brought to Europe by the Dutch in 1610. Green tea was first used about 1715. During the first years of its introduction, the price of tea was from £5 to £10 per pound. In 1784 the duty on tea was reduced from 50 to 12½ per cent.; at the end of the century it was 100 per cent.; in 1863 it was reduced to one shilling per pound, in 1865 to sixpence. Tea has increased rapidly in favour in Great Britain. Within the first fifty years of its general introduction, namely, in 1726, the annual imports had risen to 700,000 pounds. Forty years later, in 1766, the consumption was tenfold, namely, seven millions of pounds; in 1858 it was more than seventy millions; it is now about twice seventy.

There are many different methods of preparing tea for the table, even to the partaking of the whole leaf ground to a fine powder and mixed with hot water. Usually, however, the clear infusion only is swallowed; the residual spent leaves being small in quantity in relation to that of one's daily food and not having any great food value. The soluble matter in the leaves is most readily extracted by water at or very near to the boiling temperature; hence in making the infusion for the table the best result is obtained when a teapot is used which by any convenient plan can

be heated to as near the temperature of boiling water as is practicable, the leaves being placed in the hot empty tea-pot, and water which a moment before was boiling, immediately poured over them. The leaves may soak in the water from two to seven minutes, according as a fragrant, light-coloured, stimulating infusion is desired, or a darker coloured rough-tasting fluid is preferred. The proportion of tea to water is a matter of taste ; the formula "a spoonful apiece and one for the pot" is perhaps sufficiently suggestive if somewhat elastic. How to produce several quarts of the beverage all good alike, from a pot of a capacity of two to three pints, is a problem for the fairer sex to solve. A solitary chemist in his laboratory boils water in a glass beaker, and when it has boiled about one minute turns off the source of heat, drops in his teaspoonful of tea, places a saucer over the mouth of the beaker, and for three to four minutes feasts his eyes on the slowly falling leaves and the gradual colouring of the infusion from a pale sherry tint to a dark golden. He then decants the clear bright fluid into another beaker, and, according to his wisdom, adds nothing, or sugar and milk, or cream (if at hand). A portion is at once poured off, cooled to drinking temperature and—enjoyed. And then another portion is cooled and enjoyed, and, at proper intervals, others, the last being still a sipped draught of delicious *hot* tea. It is a great luxury to have a hot stock to the last. No doubt that advantage involves the cooling of each portion before drinking, but for this operation there are those who "when nobody's nigh" act on the belief that a saucer is the very thing, indeed that it was originally made for the purpose. The semi-exhausted leaves are thrown away ; a connoisseur never ventures on a second brew. Soft water is more economical than hard for tea making ; for the calcareous matter in hard water injuriously affecting the quality of the beverage, more of the leaf has to be used to produce full fragrance and flavour. Soft water more readily extracts the soluble matter of the leaf, hence, by the way, the infusion should stand a less time with soft than with

hard water. A pinch of "soda," that is, carbonate of sodium, will soften the water, and dissolve much additional matter from the leaf, but it is apt to impart an undesirable flavour to the infusion.

Composition of the tea leaf. Tea leaves yield to water from about ten to forty per cent. of their weight, according to the length of time of infusion. The infusion quenches thirst by virtue of its water. It stimulates, producing its most highly prized effects, by virtue of an inodorous, slightly bitter, white, beautifully silk-like, crystalline, substance termed *theine*, present to the extent of only about one-fiftieth part of the weight of the leaves. The fragrance and much of the flavour of the leaf, and some of the pleasant effect on the system, are due to a very small proportion of a volatile oil. The colouring matter does not differ from that of most leaves. The roughness on the palate is due to tannin, a constituent of oak-bark and of very many plants besides tea, and familiar to us as the principle which converts skin into leather. The roughening effect of some tea in the mouth, especially if the infusion has stood for some time on the leaves and become "woody," is, in fact, the tanning process. The effect is continued in the throat and into the stomach, the tannin similarly attacking any food, especially animal food, that may be there. The quantity of tannin consumed in drinking tea is small, and does not appear to affect persons in health; but possibly it is the one constituent that causes the unpleasant dyspeptic effects in those with whom tea disagrees. On the whole, the less tannin in the beverage the better: no great amount comes out in the first five minutes of infusing. As regards the other substances in tea the following table may if necessary be referred to. It shows the average composition of tea according to Eder, and is one of the most recent of the many published analyses of tea.

A. Soluble in water: 40 per cent. *a*, Organic substances. —Hygroscopic water, 10·0 per cent.; tannin, 10·0; gallic acid, oxalic acid, and quercetin, 0·2; boheic acid, 0·1; theine, 2·0; tea oil, 0·6; albumenoid matters, probably

legumin, 12·0; gummy substances with dextrin and sugar, 3 to 4 . . . . . *b*, Mineral substances, 1·7, composed of: potash, 0·938; soda, 0·014; lime, 0·036; magnesia, 0·051; ferric oxide, 0·024; manganese, trace; phosphoric anhydride, 0·133; sulphates, trace; silica, 0·021; carbonic anhydride (in the ash) 0·430; chlorides, trace.

B. Insoluble in water: 60 per cent. *a*, Extracted by ether. Chlorophyll, 2·3; wax, 0·2; resin, 3·0; colouring matter, 1·8; extractive matter soluble for the most part in nitric acid, 16·0; cellulose, 20·0. *b*, Albumenoids, 12·7. *c*, Mineral substances, 4·0, composed of: potash 0·290; soda, 0·052; lime, 0·584; magnesia, 0·592; ferric oxide, 0·045; manganese oxide, 0·019; phosphoric anhydride, 1·031; sulphuric anhydride, 0·046; silica, 0·680; carbonic anhydride (in the ash), 0·744; chlorides, trace.

The different kinds of tea and different samples of one kind vary somewhat in their proportions of tannin and of substances soluble in hot water. These points are fully illustrated in the following tables by Eder. The difference in the proportion of soluble matter removed during the first infusion as compared with that taken out by continued infusion is very striking.

Designation of the kind of Tea leaf.	Percentage.							
	Original leaves.				Leaves once infused.			
	Tannin.	Extract soluble in water.	Total ash.	Ash soluble in water.	Tannin.	Extract soluble in water.	Total ash.	Ash soluble in water.
Black Congo, No. 1	11·20	40·30	5·43	2·83	4·14	10·20	3·02	0·94
,, ,, No. 2	10·10	39·40	6·21	1·55	5·65	15·30	4·80	0·46
,, ,, No. 3	8·36	37·60	6·05	2·32	3·31	8·50	4·27	0 39
,, Kaisow Congo . . .	9·28	37·50	5·30	1·98	..	..	..	..
,, Moning ,, . . .	11·32	39·90	5·03	3·03	3·73	12·90	3.88	1·27
,, Congo (ordinary) . . .	8·24	31·70	6·12	2·73	..	..	..	..
,, Souchong, No. 1 . . .	8·16	34·40	5·27	2·90	2·51	12·40	..	..
,, Assam Souchong . . .	10·95	44·30	5·22	3·09	5·07	19·70	4·96	1·05
,, Peko bloom tea, No. 2 .	11·76	42·70	4·98	3·10	..	..	..	..
Green Haysau, No. 1 . . .	12·44	43·20	4·89	2·77	5·36	13·20	3·41	0·74
,, gunpowder, No. 1 . .	12·43	39·60	5·09	2·76	..	..	..	..
Yellow Japan tea	13·07	39·50	5·81	2·73	2·62	12·00	3·40	0·47

From analyses of a number of samples of different kinds of tea, Eder gives the following as representing the composition of each :—

Designation.	Percentage.			
	Tannin.	Extract soluble in water.	Total ash.	Ash soluble in water.
Black tea. Souchong and Pouchang . .	9·18	38·30	5·88	2·85
Black tea. Congo	9·75	37·70	5·70	2·41
Black tea. Bloom tea	11·34	40·00	5·27	2·59
Yellow tea	12·66	40·80	5·68	2·64
Green tea (Haysau and gunpowder) .	12·14	41·80	5·79	2·95
Black tea (average of 25 samples) .	10·09	38·70	5·62	2·75
Yellow and green tea (average of 9 samples).	12·40	41·30	5·73	2·79

Gibson, after Payen, gives the annexed Table to show the nature and amounts of the dissolved solids in a cup of tea (seven fluid ounces), containing average amounts of cream (half-an-ounce), and of sugar (100 grains).

	Grains.
Caseine or cheesy matter from the cream . .	5
Fat and milk sugar in the cream	30
Added sugar	100
Extract of tea leaf (mineral, $4\frac{3}{4}$; organic $16\frac{1}{4}$) .	21
Mineral matter in cream	1
	157

The names of the varieties of tea are endless. For the most part they represent the district where the tea is grown, or some peculiarity in the tea. "Souchong, or Sian Chung, means *little plant;* Hyson, from Yu Tsien, *before the rains*, or from Hichun, *flourishing spring*, from the fact of the leaves being gathered early; Bohea, from the Bw-i Hills, where this tea is produced." Scented tea acquires its added odour and flavour from fragrant flowers placed in contact with the tea leaves.

Owing to the vigilance of the Custom House authorities, adulterated tea now seldom or never gains access to this

country, and it rarely, if ever, is adulterated afterwards. An artificial greenish bloom was formerly given to young tea by dusting with Prussian blue, etc., before exportation. This faced tea is not now met with in England. Tea of a specially rich and delicate flavour is comparatively rare, and, like a given wine of special flavour, commands a high price. Nine times out of ten tea is worth the money that is asked for it. A mixture of teas is generally desirable; a grocer who knows his business can be trusted to properly "blend" his teas.

Tea-drinking to excess is only less harmful than alcoholic drunkenness.

CHAPTER II.

COFFEE.

THE effect of the beverage coffee is more or less that of tea. Like tea, it stimulates, and by virtue of identically the same principle—the beautiful white silky and extremely potent but almost tasteless substance, indifferently termed *theine* or *caffeine.* Like tea, the beverage contains a minute amount of one of the many known volatile oils, giving characteristic fragrance and flavour, and to which some of the effects of coffee are due. Thirdly, like tea, it contains a variety of the rough or astringent substance termed tannin, but in smaller quantity than the variety present in tea. But while tea has certain flavours and odours conferred on it during the hay-like fermentation the leaves undergo after collection, coffee contains certain empyreumatic or fire-born colouring and flavouring substances—products of the action of heat during the roasting operation which the seeds must undergo before they are ready for use. These products have their own effects when the beverage is swallowed, and they modify the effects of the other constituents. When *café noir* is taken immediately after an elaborate dinner they may usefully check a digestion over-stimulated by alcohol, but at other times strong coffee may unduly retard digestion. Properly prepared, and taken in proper quantities, coffee is a beneficial beverage, having its own peculiar charms for the senses. Respecting its exact physiological action, Fort, after experimenting on himself, agrees that coffee acts on the central cerebro-spinal nervous system, the brain and spinal cord, in fact, and their respective nerves, promoting activity of the different functions. In moderate quantities it exerts its milder action, slightly stimulating the brain, which is then less inclined for sleep

and works with increased activity. In stronger doses the brain is more and more highly excited, sleeplessness may supervene, followed by cramp in the muscles, pains in the stomach, a disordered intestinal canal, and a disturbance of action of the heart.

The coffee shrub or evergreen tree, *Coffea arabica*, when mature, is ten to twenty feet high, its appearance somewhat suggesting, perhaps, that of the common laurel. It has sharp-pointed oval leaves, white fragrant flowers clustered round the stem at the base of the leaves, the flowers being succeeded by red or purple fleshy cherry-like fruits or berries, containing a pair of the bluish-green seeds we term coffee. The plant has been known to the southern Abyssinians from time immemorial. It is largely cultivated in Asia and America. The seed was used in Persia in the ninth century; Abyssinia gave it to Arabia early in the fifteenth century; in Constantinople, notwithstanding clerical opposition, it was freely employed in the sixteenth century; in the seventeenth century, at about the same time as tea, at all events in 1652, it found its way to England (see the 'Philosophical Transactions of the Royal Society,' vol. xxi. page 311). The first coffee-house is said to have been opened in George Yard, Lombard Street, London, by a Greek named Pasque, brought from Turkey by a merchant named Edwards. It was introduced to Paris by Solyman Aga in 1669, and the first café was opened at the fair of Saint Germain by an Armenian, in 1672.

To fit the coffee seed for use it is always roasted, an infusion of raw coffee having only a slightly sweetish and mawkish taste. The roasting operation is either simple, like the parching of peas on a fire-shovel, or elaborately conducted in silvered revolving cylinders, heated cautiously over a specially fitted furnace. The greenish-blue seeds become brown, not only superficially like a piece of toasted bread, but to the centre. Much moisture escapes, with some caffeine, while the heat converts the sugar and some of the natural fat, etc., of the raw seed into carbonic acid gas, palmitic acid, acetic acid, and an oil, termed by

Burnheimer its investigator, caffeol, all of which escape in the vapours, while other products, and notably the brown colouring substance, somewhat resembling that of burnt bread or burnt sugar, remain with the roasted seed. The skin of the seed, which cracks off during the operation, is thrown away. If the coffee is roasted to a reddish-brown or chocolate-brown, it loses about fifteen per cent. of its weight, and swells to about one-third more than its original bulk ; roasted to a chestnut-brown, or to a blackish-brown, it loses from a fifth to a quarter of its weight, and swells until it is about half as large again as it was originally.

The following Tables, from a collection by Kensington, show the relative composition of raw and roasted coffee.

COMPOSITION OF COFFEE.

	Raw.	Roasted.
Water	8·26	0·36
Cane sugar	8·18	1·84
Caffeine	1·10	1·06
Fat	11·42	8·30
Gluten	10·68	12·03
Gum, tannin, etc.	14·03	26·28
Woody tissue, etc.	42·36	44·96
Ash	3·97	5·17
	100·00	100·00

But coffee varies considerably in composition, as shown in the following Table by Levesie.

—	Gummy Matter.	Caffeine.	Fat.	Tannic and caffetannic acids, etc.	Cellular tissue.	Ash.	Potash.	Phosphoric acid.
Finest Jamaica plantation.	25·3	1·43	14·76	22·7	33·8	3·8	1·87	0·31
Finest green Mocha.	22·6	0·64	21·79	23·1	29·9	4·1	2·13	0·42
Ceylon plantation	23·8	1·53	14·87	20·9	36·0	4·0	..	0.27
Washed Rio .	27·4	1·14	15·95	20·9	32·5	4·5	..	0·51
Costa Rica . .	20·6	1·18	21·12	21·1	33·0	4·9	..	0·46
Malabar . . .	25·8	0·88	18·80	20·7	31·9	4·3	..	0·60
East Indian . .	24·4	1·01	17·00	19·5	36·4	..	..	..

Half a pint of good coffee with about three quarters of an ounce of cream and about a quarter of an ounce of sugar—an average breakfast portion—has the following composition, viewed as an article of food. The beverage quenches thirst by virtue of its water; stimulates chiefly by its caffeine; warms by the true burning of its fat, sugar, and gummy matter, etc., after its products of digestion get into the blood, and nourishes by virtue of its casein, and whatever nitrogenous or glutenoid material may be dissolved from the roasted and ground seed.

	Grains.
Casein or cheesy matter from the cream . .	$7\frac{1}{2}$
Fat with sugar from milk and from seed . .	41
Added sugar	140
Extract from coffee seed (mineral, 11 ; organic, 41)	52
Mineral matter in cream	$1\frac{1}{2}$
	242

To prepare an infusion of coffee from the ground bean is a very simple operation; to prepare a bright infusion, having the maximum flavour and aroma from a minimum amount of the ground bean, is less easy. Put about an ounce of ground coffee in a pot previously made hot; pour on about a pint of *boiling* water; keep the mixture hot, but not boiling, for about five minutes, frequently stirring that the coffee and water may come fairly into contact; clear the spout by pouring out some of the mixture, and pouring it back into the pot; put on the lid and let stand for a few minutes until the "grounds" have settled and the beverage is clear. This is simple infusion; decoction, that is, boiling the coffee with the water, is quite unnecessary, while the delicate volatile aroma is rapidly carried off by the steam. But the best principle to apply in preparing coffee for the table is that of percolation, by which water at or close to the boiling temperature is passed through the coffee slowly, little by little, into a closed receptacle beneath. It is a sort of filtration of hot water through coffee. Each drop of the hot water passes over a great many particles of the powder, getting stronger and stronger

as it descends, while each particle of the powder is subjected to exhaustion by a continuous succession of drops of the slow stream of hot water. There are many contrivances for applying this principle. The most simple is a flannel bag suspended in the mouth of the pot. If the principle is rightly apprehended there will be no occasion to remind the operator that the water must pass through the coffee and not through the exposed upper sides of the bag. The more elaborate contrivances are expensive machines.

Mocha coffee is so named from the seaport town in Yemen, southern Arabia, from which much coffee is exported. It has a yellowish hue. The French islands of Martinique in the West Indies and Bourbon in the Indian Ocean furnish highly prized trade varieties. Others come from Ceylon, Brazil, Central America, the British West Indies, and other countries.

The consumption of coffee in Great Britain has decreased to one-half within the past thirty years, while that of tea has increased three or four-fold. This is largely due to the facility with which tea is prepared for the table as compared with coffee. Tea also agrees with almost everybody; coffee not unfrequently fosters indigestion. A stock of tea leaves is always ready, and does not materially deteriorate, indeed sometimes improves by keeping; while coffee, in perfection, is only obtainable from the properly roasted, and properly and freshly ground, beans. To purchase them roasted increases the disadvantage; to purchase the beans roasted and ground adds to the difficulty of getting a good cup of coffee as compared with a good cup of tea. The normal or standard effect of tea on the system is more easily understood and appreciated and acted on than that of coffee.

Coffee appeals more strongly than tea to the eye, the nose, and the palate, and, as everyone should understand who has ever drunk "toast water," or has seen highly dried malt infused in brewing porter—everyone should comprehend that not only roasted coffee yields an aromatic dark coloured beverage, but any roasted substance which like roasted coffee contains burnt sugar, or contains burnt gummy, starchy, or similar matters, necessarily gives,

with water, an aromatic, dark coloured beverage. Roasted bread or buiscuits, roasted figs or dates, roasted chicory root, and scores of such things, yield brown fragrant beverages not altogether unlike that of coffee, because produced by substances similar to those in coffee. And those beverages not only quench thirst as well as coffee, all containing the same thirst-quenching fluid, water, but they produce certain refreshing effects on the persons who drink them. The roasted seeds of *Cassia occidentalis*, "Negro coffee," yield an infusion which can scarcely be distinguished from that of coffee, and which is indeed used as a refreshing beverage by whole communities on the coast and in the interior of Africa. Acorn "coffee" is not unknown on the continent. But not one of these things contains the characteristic stimulating principle of tea and coffee, the theine or caffeine. There is no inherent objection to the mixture of chicory, or any of the allied substances, with coffee. The law of this country recognises trade in such mixtures if done openly and without fraud. The addition of such things to coffee is an admixture, not an adulteration. But the condition of things which brings about the use of such mixtures tends to decrease the consumption of coffee, and, the instinctive desire for a nerve-stimulant remaining, to increase the consumption of tea.

Coffee Essence or *Coffee Extract*.—Fluids for the extemporaneous preparation of a cup of coffee by mere admixture with hot water are sold under these names. They are stated to be infusions so concentrated as generally to represent, more or less successfully, an equal weight of ground coffee, sweetened or unsweetened. If properly prepared from good coffee, they should yield from one to two per cent. of crystallised theine when tested by the following process. Mix in a mortar with a little magnesia; warm for a short time; cool thoroughly; evaporate nearly to dryness; shake with ether; pour off the ethereal fluid; twice repeat this ethereal washing; evaporate the mixed ethereal fluids to a low bulk; set aside that the residue may become dry. It would be well for persons buying considerable quantities of these preparations to apply this test.

CHAPTER III.

OTHER "TEAS."

Coffee-leaf Tea.—The leaves of the coffee tree contain the same stimulating principle as the bean—theine. Indeed an infusion of the leaf is used as a beverage by some millions of people, chiefly in Sumatra. The leaf is not fermented, like the tea leaf, but roasted like the coffee berry. It contains a volatile oil giving the full berry-like aroma, and a variety of tannin. The infusion is usually drunk with sugar and cream. It closely resembles the seed beverage. The price of the roasted leaves in Sumatra is about three halfpence per pound.

Maté or Paraguay Tea.—The dried and slightly roasted leaves of the Brazilian holly, *Ilex paraguayensis*, are used by many millions of people in Peru, Paraguay, Brazil, and elsewhere in the form of an infusion resembling our tea and coffee infusions. Maté stimulates, for it also contains theine and a volatile oil. Tannin is present. The infusion is prepared for drinking, not in a teapot with a spout but in a cup, the maté. It is sweetened with a lump of burned sugar, and lemon juice is occasionally added. It is sucked through a tube, the immersed end of which is a pear-shaped strainer.

Kola.—On the west coast and in central Africa, the fruit, or seeds of the Kola tree, *Sterculia acuminata*, and other species of the *Sterculia*, or *Kola*, or *Cola*, are used for chewing (or, rarely, infusing), as one might chew cocoa. It was first analysed, by the author of this Handbook, in 1865, and found to bear a close resemblance in composition to tea and coffee, except in containing much starch. The specimens were supplied by the late Dr. Daniell, who brought them from the Gold Coast, and who, suspecting

the presence of theine, had extracted a substance which afterwards proved to be that principle.

Kola occupies a prominent place in all ceremonies connected with the hospitalities, the marriages, the religion, and even the wars of the aborigines.

Guarana Tea, or rather *Guarana Cocoa.*—The dried and slightly roasted seeds of the *Paullinia sorbilis* are roughly ground and made into a chocolate-like paste in sausage-shaped masses by the Brazilians, who mix it with water and sweeten and drink the beverage as we drink cocoa. It was found by Dr. Stenhouse to contain four or five per cent. of theine.

Theine and instinct.—It is remarkable that the instinct of man, even in his savage state, should have led him to select, as the bases of common beverages, just the four or five plants which out of many thousands are the only ones, so far as we know, containing theine.

Coca or *Cuca.*—To the foregoing may be added the leaf of the *Erythroxylon Coca* which is chewed by the natives of South America for its sustaining power. Like tea, coffee, kola, and maté, coca appears to be a powerful stimulant, its active principles, *cocaine*, *hygrine*, etc., enabling a man to live and work on the store of food in his own flesh for a much longer time than would be possible without any such spur. It does not appear to be employed in the form of a "tea" or actual beverage.

Tea Substitutes.—Under this name Johnson in his 'Chemistry of Common Life' gives the following list (page 633) of substances employed for producing beverages commonly called tea, but not containing, so far as chemical examination has at present gone, any stimulating substance even resembling the theine of tea.

Dr. Hood recommends the following "tea" as a beverage in place of ordinary tea for certain gouty and dyspeptic patients. Infuse twelve camomile flowers and a saltspoonful each of grated dry lemon-peel and grated ginger in about a pint of boiling water. Serve from a teapot into teacups as usual.

Name of Plant.	Natural order.	Where collected and used.	Popular name.
Catha edulis	Celastraceæ .	Arabia . .	Arabian tea.
C. spinosa		Abyssinia .	Kaat or Kāt.
Rhamnus theezans . .	Rhamnaceæ .	China . .	Theezan tea.
Ceanothus americanus .	do. . .	N. America .	New Jersey tea.
Psoralea glandulosa . .	Leguminosæ .	Chili . . .	Jesuits' tea.
Cyclopia Vogelii . . .	do. . .	Cape . . .	Boer tea, Bush tea, or Cape tea.
Prunus spinosa ½ . . .	Rosaceæ . .	N. Europe .	Sloe and strawberry tea.
Fragraria collina, or F. vesca ½			
Glaphyria nitida (flowers)	Myrtaceæ . .	Bencoolen .	Long-life tea.
Leptospermum scoparium and L. Thea.	do. . .	New Holland	Tea plants.
Melaleuca genistifolia and M. scoparia.	do. . .	do. . .	Tasmanian tea.
Myrtus Ugni	do. . .	Chili . . .	(?)
Helichrysum serpyllifolium	Compositæ .	Cape . . .	Colony tea.
Gaultheria procumbens .	Ericaceæ .	N. America .	Mountain tea.
Ledum palustre . . .	do. . .	do. . .	Labrador tea.
L. latifolium			James's tea.
Ocymum album . . .	Labiatæ . .	India . . .	Toolsie tea.
Monarda didyma . . .	do. . .	N. America .	Oswego tea.
M. purpurea			
Micromeria Thea-sinensis.	do. . .	France . .	(?)
Salvia officinalis . . .	do. . .	N. Europe .	Sage tea.
Hydrangea Thunbergii .	Lythraceæ .	Japan . .	Ama Tsja, tea of heaven.
Acæna Sanguisorba . .	Sanguisorbaceæ . .	New Holland	"Burr" of colonists.
Styrax Alstonia . . .	Styracaceæ .	New Granada	Santa Fé tea.
Capraria bifolia . . .	Scrophulariaceæ . .	C. America .	West Indian tea.
Correa alba	Rutaceæ . .	New Holland	Cape Barran tea.
Lantana pseudothea . .	Verbenaceæ .	Brazil . .	Capitão da matto.
Stachytarpheta jamaicensis	do. . .	Austria . .	Brazilian tea.
Chenopodium ambrosioides	Chenopodiaceæ . .	Mexico and Columbia .	Mexican tea.
Viburnum cassinoides .	Caprifoliaceæ	N. America .	Appalachian tea.
Prinos glaber	Aquifoliaceæ	do. . .	
Angræcum fragrans . .	Orchidaceæ .	Mauritius. .	Bourbon or Faham tea.

In addition to the above the Solidago odora furnishes Blue Mountain tea or Golden rod tea; the Smilax glyciphylla affords Botany Bay tea; Sida canariensis, Canary tea; Ilex vomitoria, Carolina tea; Cordia globosa, West Indian tea; Eugenia variabilis, Malay or Bencoolen tea; Primula veris, Cowslip or Paigle or Pagle tea; Sassafras officinalis, Sassafras tea; Amorpha canescens, Wild tea; Eupatorium Ayapana, Ayapana tea.

CHAPTER IV.

COCOA AND CHOCOLATE.

COCOA is an article of food rather than of drink, for, as will be seen by the following Table, it contains much flesh-forming and warmth-giving substances, and these are all eaten after due admixture with hot water to form a thick soup-like mixture. Nevertheless the proportion of water used in preparing the mixture is so large that it partakes of the character of a beverage. Besides, cocoa contains a stimulating principle, named theobromine, which is very closely allied to theine, the latter being in fact what a chemist would term methyl-theobromine. And, again, cocoa is sometimes boiled with water, the more nourishing parts, which are not soluble, strained off, and the decoction, which is truly a beverage, alone drunk. By the way, the latter is the only truly soluble form of cocoa; the so-called "soluble cocoa" should be termed "miscible cocoa," for it does not really dissolve in water.

COMPOSITION OF COCOA.

	Caked.	Flaked.
Water	3·77	3·60
Fat (cocoa-butter)	50·20	54·90
Albumenoid (glutenoid) matter	16·64	16·51
Starch, gum, cellulose, etc.	25·47	21·27
Theobromine (usually 1 to 2 per cent)	·70	·47
Mineral matter (ash), chiefly phosphate of potassium	3·22	3·25
	100·00	100·00

Cocoa is the roasted and ground seed of a tree which Linnæus named *Theobroma*—food of the Gods—the *Theobroma Cacao.* It grows in the West Indies, Central America, and other countries, to a height of fifteen to forty

feet. The fruit has the shape of a thick short cucumber, or long melon containing many beans or seeds. As met with in this country in the dried condition about twenty of the seeds would weigh an ounce. Cocoa was brought to England by Columbus early in the sixteenth century, but was not used until after the middle of the seventeenth century.

To fit cocoa for consumption, the beans are roasted, like coffee, the husk generally removed, and the kernel crushed and sold as cocoa nibs. Or the roasted bean is ground and sold as a powder, or rolled while hot into a paste which when cold is sold as flake or rock cocoa. Some cocoa has a portion of its fat removed, cocoa being too rich in fat to suit all systems. To some, much starch is added, a cheaper, less rich preparation being thereby produced.

Cocoa-tea is a beverage of inferior value made by boiling the husks or skins of the bean in water. Besides theobromine, the husks contain a very little theine. The kernels also contain some theine but in still smaller proportion.

Chocolate is cocoa to which a large proportion of one of the varieties of sugar is added, sometimes also farina, together with vanilla or other flavouring material, the whole being mixed into a paste under hot rollers, and then pressed into the various cakes, etc., familiar to the public.

CHAPTER V.

MILK.

No sharp line separates foods from drinks. Most food contains water and many true beverages contain food. *Milk* however is far less a beverage than a food. For infants and the young of animals it is a perfect food containing flesh-forming substances, bone-making material, warmth-producing constituents, and water, the latter essential as a vehicle for the conveyance of the solid portions to the blood and for maintaining the whole animal system in a flexile condition. For adults milk is in a sense too good a food, it is too easily assimilated, not lasting enough, it is too fluid. When, however, the growing or grown person is thirsty and also not disinclined for a little easily swallowed nourishment, cow's milk comes in as a beverage. From this point of view milk may receive some notice in this Handbook, but for full information respecting it the reader is referred to treatises on food.

Composition of Milk.—The proportion of water in the milk of all animals falls between eighty and ninety per cent. Cow's milk contains on the average 87 parts of water to 13 of dissolved solids or suspended fat. The fat is familiar as butter ; under the microscope it will, in milk, be seen to be suspended in the form of minute corpuscles in a colourless watery fluid. The fat is fluid at the normal temperature, and remains so until the milk is well agitated by churning or otherwise, or until the milk is frozen. Good milk contains three to three and a half per cent. of butter. On standing, milk separates into an upper portion still more opaque than milk, called *cream*, containing most of the butter globules, and a lower portion containing fewer of the globules and therefore less opaque. The effect is immediately and more thoroughly produced by whirling

the new milk in a drum, when the heavier watery portion (skim milk) flies to the further part of the mass and the lighter fatty portion (cream) may be collected from the central part of the drum. Good milk yields ten or twelve per cent. of cream. A variety of sugar termed *lactose* occurs in solution in milk to the extent of about five per cent. The fat and sugar burn in the system by aid of the inhaled oxygen of the air, and contribute to the maintenance of that animal warmth without which life would cease. Dissolved by the aid of a little alkaline mineral matter there occurs in milk about four per cent. of *casein*, the basis of cheese. The addition of an acid to milk causes the precipitation of the casein in the form of a curd (cheese) containing the fat (butter) globules previously suspended in the milk, a clear yellow liquid (or whey) remaining. *Curds and whey* are also produced on adding to milk a piece, or an infusion, of *rennet*, the salted and dried inner membrane of the fourth stomach of the calf. The exact action of rennet is not known. It is the casein which is the flesh-forming constituent of milk. The mineral matter in milk remains as ash when milk is boiled until all water is dissipated, and the residue is heated until all carbonaceous matter is burnt off. It amounts to about three-fourths of one per cent. It chiefly consists of the phosphates of potassium, calcium, and magnesium, and is the bone-making material.

The dissolved and suspended substances render milk slightly heavier than water. A vessel exactly holding two pounds of water would hold about two pounds one ounce of milk. Or technically, the specific gravity of milk in relation to 1000 parts of water is from 1030 to 1035. Specific gravity alone, however, as taken by the form of hydrometer termed a *lactometer*, or even by more delicate means, is of little value as an indication of the richness of milk, the butter and the other solids exerting an influence in opposite directions. The butter in milk, and therefore the cream, varies somewhat in proportion; otherwise the milk of healthy cows is curiously regular in composition.

The non-fatty solids in the mixed milk of a herd or dairy of healthy cows is almost a constant quantity, namely, 9·3 per cent. A lower proportion of non-fatty solids in a sample of milk points to the addition of water. Thus, supposing that 100 grains of a specimen of milk evaporated to dryness, and all butter extracted from the residue by ether, yielded a non-fatty residue of 7·44 grains, the specimen would probably be four-fifths milk and one-fifth water. For if 9·3 indicate 100, then 7·44 indicate 80. Occasionally, under exceptional circumstances, a sample of genuine milk might be slightly poorer than that from a healthy herd, and therefore, in England, for legal purposes, a standard of nine per cent. by weight of non-fatty solids and 2·5 per cent. of butter-fat has been proposed. Only in the rare cases of milk containing unusually large proportion of butter-fat would any milk yielding less than 9 per cent. of non-fatty solids be regarded as genuine. And, again, no milk would be considered genuine if it yielded less than 2·5 per cent. of fat, not even in the rare case of its containing an unusually large proportion of real non-fatty milk-solids. Half-starved cows might yield milk below these standards, but it could scarcely be considered to be normal, or better fitted for food than milk watered after leaving the cow. If, however, such milk be treated as genuine, a standard of 8·5 of non-fatty solids will not be too low. Even in that case dairy milk supplied continuously or even frequently with less than nine per cent. of non-fatty solids would rightly be regarded as containing added water.

Koumiss is sour mare's milk skimmed and fermented. It is alcoholic. *Kephir* is a somewhat similar beverage made from the milk of cows and of other animals. Koumiss is used in the Steppes of Russia, Kephir in Caucasia.

There is close resemblance in general character and in composition between the milk of all animals. It varies slightly in any one animal according to period of lactation, nature of food, season of the year, and, indeed, according as it is the portion first drawn or last drawn from the natural reservoir.

CONCLUSION.

Animal life is maintained by aid of solid, warmth-giving, bone-producing, and flesh-forming nutritive substances, by stimulating substances, and by water ; the water being in the form either of actual water, or of the various beverages we daily imbibe. The water conveys the nutrients to all parts of the system, it similarly conveys the stimulants, and it also acts *per se* in keeping the tissues and organs in an elastic vital condition. The function of nutritious food is evident. The office of water, no matter in what form of beverage, is clear enough. The purpose served by stimulating substances is less obvious. It would seem, however, that they do the important work of aiding the system, whenever necessary, to digest and to store up food, and to utilize its existing stores of fat and of flesh. A stimulant does some such work as this whether it belong to the tea class, as, for example, coca ; the alcoholic class, as, for example, brandy ; or the clear soup class, as, for example, beef-tea. In other words, the purpose of stimulants is, apparently, to stimulate the system the better to live upon itself, and the better to replenish its store of life-sustaining, work-performing, flesh and blood. The imprisoned miner, having no food ordinarily so-called, but having stores on his own frame, is able to exist for many days if only, by a periodical sip of brandy, he can stimulate his organs to utilize those stores. Of course he daily gets thinner, the elements of his thus used flesh passing away as gases and vapours from his lungs and skin. The Indian performs a journey of two or three days on foot without any so-called food ; but he really lives and works on the flesh stored on his own frame, and lives satisfactorily if only he can chew his coca, and so obtain the stimulus that shall induce his flesh to yield so much extra force. Of course he, too, daily

decreases in weight, and must afterwards renew his jaded body by rest and nourishing food. The invalid unable to take solid food can generally take stimulating beef-tea, and thus stimulate his own flesh to maintain his life until he again is able to take true nourishment. That he loses flesh in the process is generally too apparent. These are extreme cases of what appears to be the ordinary action of stimulants when taken in proper quantities—taken in excessive quantities stimulants become poisons more or less insidious.

Alcohol, tea, and the more soluble extract of meat, may, then, be said to be stimulants, not nutrients. The further elaboration of this subject, however, must be sought in works on food rather than on drink. What the author desires here to demonstrate is that whether the food, etc., be solely nutritious, or slowly stimulative, or be nutritious and stimulative as well, it must be converted into the vital fluid of our arteries by aid of water, and by water alone. This is one of the reasons why we partake of beverages. The other is that we may thereby maintain our systems in that flexile condition essential to life and to activity.

These high functions of water, no matter in what form of beverage, seemed, to the author, to demand such a study of water, and therefore, of all beverages, as is presented to the student of health and to the public in this Handbook. The beverages other than simple water, however—excepting alcoholic beverages, which are treated in another Handbook—having special points of interest beyond the interest attached to the water contained in them, also demanded special notice, and this has been accorded.

SALT AND OTHER CONDIMENTS.

BY

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SAL SAPIT OMNIA.

"For many things are swallowed by animals, rather for *condiment*, gust or medicament, than any substantial nutriment."—BROWN, *Vulgar Errours*, b. iii. c. 22.

CONTENTS.

PART I.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

CHAPTER VII.

CHAPTER VIII.

PART II.

INTRODUCTION.

If readers, judging from its title, "Salt and other Condiments," expect to find this Handbook a treatise on the condiments of all nations, or even on all those used by ourselves, they will be disappointed. Limitation of space utterly precludes the idea of a comprehensive survey of so wide a subject.

And further, as salt is the condiment, not only most acceptable to the taste, and as generally believed most necessary and healthful to the body, but the one most universally used throughout the world, and as its large consumption at home and exportation abroad have led to its becoming one of our most important industries, the greater portion of the space so limited is naturally taken up with its history, and especially with its production and manufacture in this country.

As regards "other condiments," the writer had at the outset considerable difficulty in determining in his own mind what the term "condiment" should include, or what it included in the minds of those who assigned him the present task. The Latin verb *condio*, being derived from *con*, i.e. *cum*, "together," and *duo* the ancient form of *do*, to "give," perhaps originally and strictly, when applied to gustatory matters, signified to "compound" or "concoct" something to give seasoning or flavouring. Every schoolboy has read of the "*male conditum jus*" of Horace—"the badly concocted sauce,"—which a young aspirant for the birch translated as the "badly established law." Hence *condimentum* would strictly mean some "compound" in the way of a sauce or seasoning, composed of various

ingredients, but making a homogeneous whole. But as *condio* has the further meaning of preserving and pickling substances, and generally of making food savoury, *condimentum* came to include every kind of article, liquid or solid, simple or compound, which, not being primarily food itself, was used to flavour and season food. In like manner our word "condiment" has its more restricted and its more general application; signifying in the first place the "compounds" of which sauces, curries, chutnees, etc., would be the representatives, and in the second place, all substances used as "food accessories" for the purpose of stimulating and pleasing the palate. In this latter sense it would cover the large family of "spices," oil, olives, capers, salad plants including onions and their congeners, mushrooms, truffles, and even sweets, such as sugar, honey, and preserved fruits; and last, but not least, the mineral salt. All these and many more have been classed as "condiments" by various writers and compilers of works of reference; but such a field as this cannot possibly be traversed here; and we must confine our attention almost entirely to those common condiments which are to be found on every table, viz., salt, and the occupants of the humble cruet stand, mustard, pepper, and vinegar.

And this can be done on something like an intelligible principle, because the condiments just mentioned are those specially and almost exclusively used without combination with any others, and directly by the eater, who applies them first hand to the food before him. The great majority of other condiments, using the word in a comprehensive sense, are mainly employed directly by the cook and only indirectly or second-hand by the eater. This principle of selection is not of course quite accurate, as, strictly speaking, sauces and pickles, and some other "food accessories," would come within the same category as the four common condiments of ordinary cruet stands; but it may be taken as indicating the main scope of this handbook.

Referring again for a moment to salt, though the writer

has visited the salt districts on a "voyage of discovery," and found very much to engage his attention there, the subject of salt production and manufacture does not give much scope for original writing, or for very interesting descriptions; the matter in hand being rather one in the elucidation of which statistics of production, details of manufacturing processes, and analyses of substances must necessarily occupy considerable space. At the same time the writer has endeavoured to make this a "popular" handbook, so that general readers may without difficulty gain a fair knowledge of the history of the great "popular" condiment; while those of a more scientific or practical turn may have something in the way of a reliable though small volume of reference.

In endeavouring to carry out this twofold object he is much indebted to many standard works of reference, such as Spon's invaluable *Encyclopædia of the Industrial Arts, Manufactures and Commercial Products;* and personally to the Secretary of the "Salt Chamber of Commerce," to the Managers of Mr. John Corbett's Salt Works at Stoke Prior, of the "Droitwich Salt Company," and of the "Maldon Crystal Salt Company," and further to Messrs. Bumsted, of King William Street, and other gentlemen connected with the salt trade. He only regrets that he has been unable for want of space to use more of the interesting information which they so kindly gave him.

SALT AND OTHER CONDIMENTS.

PART I.

CHAPTER I.

CONDIMENTS IN GENERAL—SALT IN PARTICULAR.

IT has been noted in the Introduction to this Handbook that it is difficult to define the exact meaning of the word "condiment," and that authorities differ somewhat as to the character and number of articles which the term should cover, some using it in a comprehensive, and others in a more restricted sense. For the purpose of the earlier part of this chapter let us take it in its wider meaning as signifying any substances used for the "flavouring" of food, and not as food itself.

Logicians have defined man as "an animal that cooks its food;" and it has generally been held that this "difference" of cooking distinguishes him fairly and logically from all other animals. But does it? Yes—at the present period of his existence: but did he always cook his food? It may be open to doubt whether he did so. If we take the Bible record (Gen. i. 29–30) we find something more than a suggestion that man in the earlier period of his existence was a vegetarian. Moreover, the formal commission to man to use the vegetable world for food was given to all other animals, and therefore probably he would not need to cook his food any more than they would. In the further commission to man after the flood (Gen. ix. 3.) "every moving thing that hath life" was given him as "meat," and allusion is made to the "green herb" given him before. Now if man was only a vegetarian before the flood, and did not cook his

vegetable food, the question may be asked whether he used condiments of any kind with it. A large or at least a certain portion of his vegetable food would necessarily be somewhat insipid, and he would almost naturally seek for something wherewith to flavour it. Salt in some form or other would soon have presented and recommended itself to him; and it would not be long before he would have discovered some vegetable productions, and especially the seeds of some herbs agreeable in flavour but too strong and pungent to eat alone or in large quantities; and thus we may suppose he would have been led to use them as "condiments." And indeed we may go further and hold that he had a natural instinct for condiments from the very beginning, if we judge from the fact that man in all ages and in all countries, as far as we can gather from history, had this instinct, and even craving.

If this be so, let us ask whether a more logical definition of man than that before mentioned would not be "an animal that uses condiments with its food"? Of course it might be answered that we do know for certain that he did so use condiments from the beginning; and it might be argued that he has only developed a taste for them, as he has for various forms of narcotics and alcohol, as his life has gradually become more artificial. Still we are confronted with the fact that there are races of human beings still living primitive, unartificial, and uncivilised lives, which have all these tastes, and indulge them in some way or other, and further so strongly develop them when opportunities are given them as to suggest that they are natural instincts. But, however this may be, we find different races of men in different parts of the world which have long selected and largely used certain condiments with their ordinary food. And, this selection it must be noted has not been based on any chemical knowledge, but apparently on some natural instinct. To take one instance out of many, it is, to say the least of it, strange at first sight that different races, dwelling remote from one another, have fixed on vegetable productions so unlike to each other as the onion and garlic, the

assafœtida plants, and the mustards—all belonging to different botanical orders—as condiments. The simple explanation is that these vegetables contain compounds of sulphur and allyl; and, as in the case of certain beverages and narcotics, men seem to have been led to this selection by a kind of human instinct, guiding them blindly as it were to plants, which were capable of yielding to the body the same or similar compounds. Future research may probably show that these compounds of allyl exercise a peculiar physiological action upon the system, by which certain of its natural cravings are allayed, and its general comfort promoted. This is rendered more probable by the remarkable circumstance that the many kinds of mustard, the use of which as condiments so extensively prevails, owe their peculiar properties to the presence of compounds of the same substance—allyl.

It seems then reasonable to suppose that a taste and even craving for condiments is a human instinct; but it may be further asked whether this taste is not instinctive in other animals than man, or at least in some of them. If it be so, then the suggested definition of man as "an animal that uses condiments with its food," is logically untenable. It is a curious and interesting question as to what extent animals take certain substances, not as a food but as a relish with food, and as of acceptable and pleasant flavour, enjoyed without any actual sense of satisfying hunger, much in the same way as a child enjoys a sweetmeat. But we can hardly pursue it here. Suffice it to say that there is evidence that animals other than man appreciate condiments, and, certain it is, that most quadrupeds and several birds have a special love of salt. Brown in his *Vulgar Errours* (III. 22.) says, "For many things are swallowed by animals rather for *condiment*, gust, or medicament, than any substantial nutriment." Horses, cats, dogs, and many other animals are attracted by substances flavoured and scented with condiments (using the term in still more extended sense), and however absurd may be the recipes for medicated baits given by Izaak Walton and

other angling writers of past generations, still it is a fact that "condited" pastes have special attractions for some kind of fish.

Ancient nations of the East, and the Greeks and Romans after them, in the luxurious periods of their histories were much given to the use of all kinds of condiments, both in their simple and more complicated forms: and as commerce brought them within reach, the people of this country came freely to use both the more highly and more delicately flavoured contributions from foreign climes in addition to their own natural productions, which in many instances were the wild growths of the fields, hedges, and woods. We may not be able to agree with the old Doctors of Gastronomy, and authors of recipes who recommended our forefathers to eat ginger with lamb; cinnamon with thrushes; mustard with mutton, salmon, pheasants, partridges, and rabbits; vinegar with roast beef and goose; and a combination of sugar and salt with divers birds: but we must not argue the question, as it would be at once said that all such combinations are mere matters of taste, and that every one has a right to "condite" for himself, as, for instance, the Russian does when he takes currant jelly with red herrings and kippers. Quite so: but at the same time we may reserve to ourselves the right to hold the opinion that there are tastes and tastes, and that some of them would be all the better for a little education. Our country boors, destined to be soon enfranchised, prefer the adulterated beer from the "Black Bull" to a bottle of Château Yquem; a rasher of musty bacon to a cut from a prime haunch of buck venison in full season and well hung; and the blue, red, and yellow daubs of scriptural personages and incidents to Murillo's Holy Family in the National Gallery. Of course this is all a matter of taste; but as "sweetness and light" extend with the franchise, and Schools of Art and Schools of Cookery make their influence felt even in remote villages, "tastes" will gradually change. But speaking more seriously we must hold that there are certain proprieties to be observed

in the use of condiments, and that in this matter the axioms of the "Physiologie du Goût" cannot be violated without the transgressor writing himself down as devoid of "taste."

Although there once existed among "the faculty" a certain amount of prejudice against the use of our ordinary condiments with the exception of salt, there now seems to be a general consensus of dietists in their favour. Being adjuncts to and accessories of food, rather than food itself, condiments are generally speaking of great value in rendering the substances we eat more palatable, and in stimulating jaded appetites. They are stimulants of the digestive organs, promoting the flow of saliva, the gastric juice, and other internal secretions, and thus they directly aid the process of digestion. Their use and value is thus summed up by Dr. Pavy in his standard *Treatise on Food and Dietetics.* He says "Condiments consist of seasoning or flavouring agents. Without being strictly alimentary substances, they nevertheless play no insignificant part in the alimentation of man, and prove of service in more ways than one. Their first effect is to render food more tempting to the palate, and thereby increase the amount consumed. We are guided in the choice of food by taste and smell, and that which agreeably affects these senses excites the desire for eating. Condiments are employed for this special purpose, and thus a flagging appetite receives a stimulant. Through their aromatic and pungent qualities they also assist digestion, the *modus operandi* being by promoting the flow of the secretions, and increasing the muscular activity of the alimentary canal. In some cases they may be further useful by serving to correct injurious properties that may belong to an article of food." At the same time, however, we are warned against the use of condiments in some abnormal conditions of health, and in all cases against their abuse. They may be indulged in to such an extent that their action on the processes of digestion and assimilation may become probably injurious by vitiating the gastric juice and affecting the coats of the stomach. They

are also provocative of thirst, which leads to the consumption of more liquid of some kind or other than is good for the system even of healthy persons. The golden rule of moderation—*ne quid nimis*—should be observed in their use, both when taken as condiments to the food on our plates, or when employed in cookery. Great chefs, like Beauvilliers, Carême, Ude, Francatelli, and other professors of the mageiric art whose names are household words, have always depended greatly on the use of condiments for their successes ; at the same time, however, they not only observed the proprieties of the combinations of condiments, but exercised great moderation in the quantity of any thing employed. Unfortunately, many cooks incompetent to develop the more subtle flavours of their materials disguise the poverty of their resources with a superabundance of condiments, and especially of the contents of the spice box. All harmony of flavour is thus destroyed, and the digestive advantages which a moderate amount of spice undoubtedly confers are lost in the nausea occasioned by the violation of the *ne quid nimis* principle.

Salt (*Sal*—ʽαλς) is the most widely accepted of all condiments. So universal has been and is its use, that it may be called the "cosmopolitan" condiment ; and so great is the craving for it and relish of it, that we are led to consider the love of it as one of the most potent of our natural instincts, and salt itself as necessary to the health and even the life of man. The fact that in no part of the world is salt unknown and unused goes far to substantiate this position. It is one of the most important of British minerals, and curiously enough the only one used as a condiment, though other mineral principles are requisite in order to build up the human frame. It is known chemically as *chloride of sodium*, or *sodium chloride*, its two constituents chlorine and sodium being united in the proportion of thirty-six parts by weight of chlorine to twenty-four of the metal of sodium. It has been stated that sodium takes fire when immersed in chlorine gas ; but Professor Wanklyn has shown that,

unless some moisture be present, such is not the case, and it is certain that metallic sodium remains bright for some time, even when immersed in liquefied chlorine anhydride. It is by far the most abundant of all sodium compounds. By the action of vitality, the sodium chloride, in presence of water, is broken up into hydrochloric acid, which is found in the gastric juice, and into soda, or sodium oxide, which is a component of the bile. Salt crystallizes in colourless transparent cubes, which are anhydrous, soluble in about three parts of cold water, and scarcely more soluble in boiling water. A saturated solution has a specific gravity of 1·205, the specific gravity of the salt being 2·125. It is inodorous, insoluble in pure alcohol, and has a purely saline taste, unmingled with bitterness, unless chloride of magnesium be present in it. At a red heat, it fuses, and becomes converted into a transparent brittle mass. The well-known crepitation which occurs when salt is thrown on the fire or otherwise strongly heated, results from the sudden expansion of water mechanically entangled among its particles.

Salt has been in use from the earliest times, and always largely sought after both by man and the higher class of animals. So eager indeed is man for it that at some time or other in almost all nations, when revenue was the most urgent, a tax was placed upon salt, since nearly everything would be sacrificed to obtain a portion of that material; and the saline earths, called "salt licks," are the greatest attraction to the wild animals of the prairie or the desert. Especially among the western nations salt has from time immemorial been regarded as so vital a necessity that no controversy as to its relish or sanitary value was ever for a moment possible. It was used from the first in some such way as water, quite as a matter of course, and with a tacit acknowledgment that it was absolutely indespensable for man's existence. Indeed the desire for salt seems an instinct implanted in the animal creation, and there is a natural craving for it, when it does not exist in sufficient quantity in food. Wild animals will travel long distances

and brave great dangers to get at the salt licks just mentioned; horses and cows are most healthy when provided with lumps of rock-salt in their mangers or pastures; and even bees will sip a solution of salt with avidity. Men will barter gold for it in countries where it is scarce, and for it husbands will sell their wives, and parents their children. In some districts of Africa salt is more expensive than the purest white sugar in Europe, and children will suck a lump of it in preference to sweetmeats. In the district of Accra, on the Gold Coast of Africa, a handful of salt is the most valuable thing upon earth after gold, and will purchase a slave or two. Mungo Park tells us that with the Mandingoes and Bambaras the use of salt is such a luxury, that to say of a man "he flavours his food with salt" is to imply that he is rich; and no stronger mark of respect or affection can be shown in Muscovy, than the sending of salt from the tables of the rich to their poorer friends.

But the existence of greater or less appetites for salt in all individuals surely indicates that this substance serves more important functions than that of merely gratifying the palate, a conclusion on which the most elementary considerations of human physiology fully substantiates. Common salt is the most widely distributed substance in the body; it exists in every fluid and in every solid; and not only is it everywhere present, but in almost every part it constitutes the largest portion of the ash when any tissue is burnt. In particular it is a constant constituent of the blood, in which it forms about half the total weight of the saline matters, and it maintains in it a proportion that is almost wholly independent of the quantity that is consumed with the food. The blood will take up so much and no more, however much we may take with our food; and on the other hand, if none be given, the blood parts with its natural quantity slowly and unwillingly. Under ordinary circumstances a healthy man loses daily about twelve grains by one channel or the other, by the secretions, the bile, and even tears, and if he is to maintain his health that quantity

must be introduced. Common salt is of immense importance in the processes ministering to the nutrition of the body, for not only is it the chief salt in the gastric juice, and essential for the formation of bile, and may hence be reasonably regarded as of high value in digestion, but it is an important agent in promoting the processes of diffusion and therefore of absorption. Direct experiment has shown that it promotes the decomposition of albumen in the body, acting probably by increasing the activity of the transmission of fluids from cell to cell. Nothing can demonstrate its value better than the fact that if albumen without salt is introduced into the intestine of an animal no portion of it is absorbed, while it all quickly disappears if salt be added, or, to put it in another way—the necessity for salt may be explained by the composition of the gastric juice. The most powerful solvent acid which insures the digestion of food is that known as hydrochloric. This is furnished entirely by the amount of salt, either chloride of sodium or potassium, taken with the food, or naturally contained in it. Unless a large quantity of this acid is present in the gastric juice, the other digestive principles are inert, or are not given out during the passage of food through the stomach. The immediate effect appears to be to stimulate the sense of taste and to increase the flow of saliva, but its preserving action is due to its power to attract moisture, by which it tends to harden whatever moist substance is brought into contact with it, and when it has obtained moisture it becomes soft, and loses its flavour. There is no other compound of chlorine which effects both of these purposes or could supplant common salt.

Salt should be used in the cooking of all vegetables, and added salt seems almost a necessity to make them palatable when cooked. Said Job (vi. 6) "Can that which is unsavoury be eaten without salt? or is there any taste in the white of an egg?"

The value of salt, as a condiment to be taken by our domestic animals has frequently been made the subject of experiment. A professor of the Michigan Agricultural

College has put it on record that he gave three bullocks salt with their food and three were kept without it. There was no other divergence in the treatment of them, but at the end of six months a marked difference began to be observable between them, and finally the animals without salt sickened and fell away, while the others continued in excellent condition. Further interesting experiments on animals by Boussingault have shown that, although salt mixed with the fodder does not much affect the quantity of flesh, fat, or milk obtained from them, yet it seriously affects their appearance and general condition; for animals deprived of salt, other than that contained naturally in the food, soon get heavy and dull in their temperament, and have a rough and staring coat. Meulin states that animals which do not find it in their food or drink, become less prolific and the breed rapidly diminishes in number. This is confirmed by Dr. Le Saine, who says, in his prize-essay on salt, that it increases the fertility of the male and the fecundity of the female, and it doubles the power of nourishing the fœtus. During the period of suckling, also, salt given to the mother renders the milk more abundant and more nutritious. It likewise accelerates growth, and gives a finer condition to the skin; and the flesh of animals fed with it is better flavoured, and more easily digested, than that of animals which do not partake of it.

The value of salt may be further estimated by the consideration of the effect on health from being unable to procure it. In barbarous times, the most horrible of punishments, entailing certain death, was the feeding of culprits on food without salt. By the old criminal law of Holland it was decreed that criminals convicted of murder under certain circumstances should be imprisoned in a damp cell, have only water to drink, and should be fed with bread made without salt. According to well-authenticated testimony the criminal always died within a very short time, and that by a death so loathsome and horrible that its symptoms cannot very well be described. It is calculated that the annual salt consumption per head in

this country amounts to 16 lbs., and that of this the average bread-eater unconsciously takes 2 oz. per week, salt being a necessary ingredient in proper bread-making. Hence we can in a measure realize what the effect of bread without salt would be. Certain experiments of the French Academicians showed that flesh deprived of its saline constituents by being washed with water, lost its nutritive power, and animals fed on it soon died of starvation. Even after a few days, with such a diet, the instincts of the animals told them it was worthless as food, and they fed on it with reluctance; indeed, for all purposes of nutrition, it was, as Liebig says, "no better than eating of stones," and the utmost torments of hunger were hardly sufficient to induce them to continue the diet. There was plenty of nutritious matter in the food, but there was no medium for its solution and absorption, and hence it was useless.

The above considerations would almost seem to suggest that salted meat would be a wholesome and desirable article of food; but it is not so. The case stands thus. The application of salt to fresh meat has very much the same effect as the application of a quick heat. It causes the fibres to contract, the meat to lessen in bulk, and the juice to flow out from its pores. Hence the reason why dry salt strewed upon fresh lean meat gradually dissolves into a fluid brine. If a large quantity of salt be applied, it penetrates so deeply that as much as one-third of the juice of the meat is often forced out by the contraction of the fibres. The effect of this upon the meat is two-fold. It diminishes the natural flavour, by removing a large proportion of the peculiar substances contained in the juice, and adding pure salt in their stead. At the same time it closes up the pores of the meat, and prevents the entrance of atmospheric air, thus diminishing the liability to decay. Thus there is a diminution in its nutritive qualities, for the juice which flows out contains albumen (white of egg), kreatine, phosphoric acid, and potash: and in proportion as these are extracted the nutritive properties of the meat are diminished. Hence one reason why long feeding on salt

meat affects the health, and why vegetable and other substances which are capable of supplying what the meat had lost, are found to be the best means of restoring it. Vegetables contain potash-salts and but little common salt, and we cannot live on them alone without adding common salt. So, on the other hand, we cannot maintain our health on salted meats unless we restore the potash-salts which they drive out of the body. As a whole, flesh-meat is eminently nutritious, because it contains *all* the materials which are necessary to build up our own flesh; but remove from it a portion of these materials, and the remainder becomes more or less useless, as bricks and stone become useless to the builder if we refuse him the requisite quantity of mortar. The analysis of the brine round salt meat shows that the process of salting must materially diminish the nutritive value of meat, for it is found to contain a large portion of the ingredients of its juice. Not only does the contraction which ensues cause the infiltrating liquid to be driven out, but the liquefied salt tends further to draw out by osmosis its diffusible organic and saline constituents. Liebig estimated the loss of nutritive value as amounting to one-third or even one-half. Soaking salted meat in water removes its saltness, but cannot of course restore the nutritive principles that have been lost. From experience it has been learnt that salted and dried food cannot be used continuously for a lengthened period without impairing the health. The well-known effect is the development of a cachectic state which manifests itself under the form of what are called scorbutic affections.

But notwithstanding the general consensus of scientific opinion as to the great value of salt, confirmed as it seems to be by physiological facts, and it may be added by our natural instinct, there are found persons who take an opposite view; and even an authority like Dr. Hassall has made bold to publish the following statement. "The function" he says "of chloride of sodium or common salt, is but ill understood. It has been asserted that it is necessary for the assimilation of the food, but this seems

not to be the case. Salt, in fact, is considered by some to be quite a superfluous addition to most of our articles of food, and nothing more than a condiment. It does not enter into the composition of any of the tissues, but is thrown out of the system in the excretions; and it has been repeatedly shown that some tribes of natives of Africa do not know the use of salt at all, or consider it a luxury and delicacy." But others have gone still further and mentioned that the use of salt is absolutely injurious. The present writer has in his possession a very curious volume of over a hundred pages, written by a Dr. Howard some fifty years ago, the protracted title of which indicates its object. It runs thus:—"Salt, the Forbidden Fruit, or food; and the chief cause of diseases of the body and mind of man, and of animals; as taught by the ancient Egyptian priests and wise men, and by Scripture; in accordance with the author's experience of many years." The work elaborates the view that salt is the source of almost "all the ills the flesh is heir to," and that abstention from it is their cure; and it is not too much to say that the writer is a painful instance as to the length people will go in perverting historical and other facts, and texts of Scripture, when they have once become the subject of a "craze," and dubbed themselves apostles of a movement. Unfortunately such extremists will ever be found, and the present age seems particularly prolific of them, whether the crusade be against the use of animal food, of tobacco, or of alcohol, or against vaccination. With such it is of little avail to adduce facts or arguments. They admit nothing which tells against their views; they contort and pervert everything; and the "Counterblast" of King James is their only type of reasoning, if reasoning it may be called. In this matter of salt some few are indeed more temperate, and state their views more moderately and intelligibly. This, for instance, is how one of the opponents of salt-eating puts the case, though with no little misconception of physiological facts. "We have," he says, "among us physiologists of no mean standing who regard

mineral salt as a poison, and as the predisposing cause, therefore, of many ailments. It is true that in its passage through the system salt remains unchanged, but this is only to say that it exerts upon the substances with which it is mingled in the system the same antiseptic qualities that it does outside the system. That is, to a greater or less extent, it prevents food from decomposing, and therefore from turning into nourishment. It is for this reason that salt is, as it notoriously is, a provocative of scurvy—a complaint which consists mainly in poverty of blood through lack of nourishment owing to the action of salt. It may be granted that a diet of flesh requires a certain small amount of salt to retard the process of digestion and assimilation, which otherwise would be too rapid, flesh not being the natural food of man, who, in all physiological respects, is a grain and a fruit-eating animal. But with our natural diet salt is worse than superfluous, saving only for the fact that we have become so accustomed to it that we do not like our food without it." That such views are held by a certain number of persons in this country may be admitted, and recently there seems to have been an attempt to organize something in the way of an anti-salt association, the members of which were to abstain from salt themselves, and to endeavour to gain converts to their opinions and practice. Some years ago there was established in New York a medical "College," the prime tenet of which was abstention from salt.

One of the chief arguments against its use was that adduced by Dr. Hassall in the quotation from his work on the Adulterations of Food, to the effect that some people exist without it. Other instances might be added to that given by Dr. Hassall. The Damaras, in South-western Africa, never take salt by any chance; and even Europeans travelling in their country never feel the want of it. But the well-water in Damara land is nearly always brackish or saline, though it appears to taste rather of carbonate of soda than of the chloride. Their neighbours, the Namaquas set no store by salt; the Hottentots of Walfisch Bay hardly

ever take the trouble to collect it; and even the wild game in the Swakop do not frequent the salt-rocks to lick them as they do in America. One tribe of New Zealanders hold salt in abhorrence. In the colds of Siberia, also, as in the heats of Africa, a similar disregard of salt sometimes prevails. Most of the Russians at Berezov eat their food without a particle of salt, though that condiment can easily be obtained at a trifling cost. Their soups, vegetables, and even roast meats, are prepared and eaten without salt. The explanation of these cases, so inconsistent with our general experience, is found in the refined instinct of the body itself. When the food we usually eat conveys a sufficiency of salt into the body, it has no occasion for more. It therefore feels no craving for it, shows no liking to it, and takes no trouble to obtain it. And doubtless, in the kind of food and drink consumed in the Damara country, and by the Russians of Berezov, either more salt, or more of sodium and chlorine, in other combinations, than is usual among us, is conveyed into the stomach, or their habits render less salt necessary to them, or cause less of it to be daily removed from their bodies. A similar explanation will to a great extent account for the cases of individuals, probably known to most of us, who take no added salt to their food, and yet seem to enjoy good health. Either some idiosyncracy of constitution, or some special habits, or some special line of diet, or all these combined, enable such persons to live without conscious discomfort on food not artificially salted.

The case, so to speak, against salt has been here stated, partly because a handbook like the present is not intended in connection with such a topic as this to advocate any particular view, but rather to put before readers a conspectus of what has been and may be said on the subject, and to suggest that any controversial matter connected with our Health might be submitted to further investigations. At the same time, however, after considering the history and "science" of salt, which seem to point convincingly to its almost universal use, and to the benefits which have as

universally resulted from it, it is almost impossible to conclude otherwise than that this cosmopolitan condiment is wholesome and necessary, and that abstention from it is likely to be injurious—in a word, according to the trade-mark of an eminent salt manufacturer, SAL EST SALUS, "Salt is Health."

As regards the quantity of salt which may be eaten with impunity, it is reassuring for those who use it in what may be deemed excess to know that the blood, as before intimated, will only take up a certain amount and no more. What salt is consumed in excess of this, the human system gets rid of by various means, mainly through the secretions, and through the pores of the skin by perspiration naturally or artificially produced. Any one who has made the experiment of tasting knows that the "tears of heat" as well as the tears of grief are very briny, and that after evaporation perspiration leaves on the skin and on the clothing an incrustation of actual salt, which may be collected in an appreciable quantity. It is possible, however, to eat salt in such enormous quantities as to produce very injurious results: but this is also the case with many other substances perfectly harmless and wholesome if taken in moderation.

But not only has the great majority of mankind long endorsed the above motto "Salt is Health," but a belief in its actively medicinal virtues in many cases has always had a large number of adherents. For both inward and outward application it has been used in a variety of ways; and it has been found useful for clysters and emetics, and, when heated, for outward application to toothache and other local pains; but more efficacious substitutes have now been found for it. If not an actual vermifuge the popular notion that the use of salt prevents the development of worms in the intestines has a foundation in fact, for salt is fatal to the small threadworms, and prevents their reproduction by improving the general tone and the character of the secretions of the alimentary canal. Some years ago there was a very widely spread craze for a mixture of brandy and salt for almost every ailment; but it probably fell into dis-

favour, as least in the eyes of those who recommended it when it was found that patients too often drank the brandy and left the salt. In recent years the Brine Baths at Droitwich have gained considerable reputation. It was remarked that during the cholera visitation in 1831, the operatives employed at the Droitwich Salt Works enjoyed an immunity from the disease. This was attributed to the fumes of the brine, more especially when it was found that certain cholera patients sent to Droitwich quickly recovered on being immersed in the hot brine. Since then the baths have been much resorted to by persons suffering from gout, and it is said that large numbers have derived considerable benefit from them. The baths form part of the Royal Brine Bath Hotel establishment.

Baths made from sea salt are recommended for many cutaneous affections, and to persons suffering from various ailments, while many in good health find great advantage from their use. Some excellent samples of sea salt for such baths can be seen among the interesting salt exhibits of Messrs. Bumsted & Co. (King William Street, E.C.), in the Southern Gallery of the Health Exhibition.

Though perhaps hardly within the scope of our immediate subject, an important connection between salt and our water supply may be here mentioned. Certain chemical tests will show when there is too much salt in water. Salt does not occur in rain water except in almost infinitesimal quantities, or in pure well water, except to the extent of little more than a grain a gallon. When therefore chloride of sodium and sulphate of lime are found present in water to a large amount, together with any considerable quantity of certain organic matters, we may, as a rule, safely pronounce the water to be impure and to have been subject to sewage contamination.

CHAPTER II.

THE SALT SUPPLY OF THE WORLD.

SALT in some form or other is so widely distributed throughout the world that hardly any region is without it, and facilities for obtaining it in greater or less abundance are within the reach of the large majority of mankind. The waters of the ocean which wash so many shores can easily be made to yield it, and masses of rock-salt more or less associated with brine springs, yield an enormous and practically inexhaustible supply; while inland salt lakes, and various soils largely admixed with salt also contribute their quota. In a word, as an old writer puts it, "salt is dispersed over all nature; it is treasured up in the bowels of the earth; it impregnates the ocean; it descends in rains; it fertilizes the soil, it arises in vegetables and from them is conveyed to animals; it is friendly and beneficent to all creatures endowed with life; and may well be esteemed the *universal condiment* of nature;" and as Dean Buckland in his "Bridgewater Treatise," speaking of rock-salt as the chief source of supply, says, "Had not the beneficent providence of the Creator laid up these stores of salt within the bowels of the earth, the distance of inland countries from the sea would have rendered this article of prime and daily necessity unattainable to a large portion of mankind; but under the existing dispensation, the presence of mineral salt in strata which are dispersed generally over the interior of our continents and large islands, is a source of health and daily enjoyment to the inhabitants of almost every region of the earth."

Apart from other sources, as rock-salt directly or indirectly, through the connection between it and brine springs,

yields the great bulk of the salt supply of the world, its formation at various depths below the surface of the earth is a very interesting geological question, which can hardly be passed over without some little notice. Probably at no period of the earth's existence did the formation of salt deposits proceed with the same activity as during the Triassic, and it is in the New Red Sandstone, Bunter Sandstone, or Keuper, and in the red or variegated marls of the Trias, that most rock-salt occurs. An idea that all rock-salt was referable to that epoch long prevailed amongst geologists, but it is now generally admitted that, although salt is found most abundantly amongst Triassic rocks, and becomes rarer as we descend into the earlier strata, it occurs in all the so-called sedimentary rocks. The oldest deposit of rock-salt known to exist, whose geological age may be said to be positively determined, is the Salt Range of the Punjaub, which may with tolerable certainty be referred to the Permian, while the deposits lately discovered at Middlesborough-on-Tees may also probably be referred to this period, as they immediately overlie the magnesian limestone.

The stratified nature of all salt deposits with their interposed beds of clay, and the salt rock itself generally possessing a perfectly stratified structure, as well defined as any other rocks of known aqueous origin, point to the fact that rock-salt must have been deposited from solution. The large quantity of selenite (crystallized hydrated calcium sulphate) so constantly found interstratified and intimately mixed with rock-salt, is, in itself, an almost conclusive proof of its marine origin, for selenite is a hydrated mineral, losing its water at a temperature far inferior to that at which sodium chloride fuses: and crystals of selenite could hardly have found their way into the solid mass of the salt, unless they had been deposited from solution simultaneously with the salt itself. In subsequent times, should the surface of the mixed bed be denuded or dissolved by the action of water, the salt would be carried away, leaving a bed of gypsum, such as is constantly found overlying and

surrounding rock-salt deposits. In some districts, as those of Magdeburg, Stassfurt, Vic, &c., beds of potassium and magnesium salts are found overlying the rock-salt. Sea-water contains similar salts, which on its being slowly evaporated are deposited in the same order as, and in similar forms to those found in connection with these German salt formations. Supposing the existence of a great Triassic estuary or lake becoming in the lapse of ages completely dried up, it is easy to imagine how the formation of these German deposits took place. Beds of salt would be formed, while the inland sea from which they were produced would become continually enriched with successive accessions of salt washed by floods from the salty soil of the surrounding country, and streams would also bring down clay and mud, so that in course of time layers of salt would be formed interspersed with beds of clay, and they might ultimately become covered up and protected by this same clay deposit. It is remarkable how frequently erupted rocks and hot springs are found in the neighbourhood of salt deposits; but this need not be taken as pointing to a volcanic origin for the salt itself. It is easy to understand how depressions and elevations produced in the earth's crust by disturbances due to volcanic phenomena would tend to the formation of estuaries and inland seas favourable to the production of salt; and many such disturbances and eruptions probably occurred during the time when the ocean bed was being raised and became dry land. Further it is to be noted that most trappean rocks are rich in iron, often ferric sulphide, whilst they are easily disintegrated by the combined influences of moisture and atmospheric oxidation. Salt itself assists in promoting such decompositions, so that islands or cliffs of trap on exposure would tend to crumble down and decompose, and under the action of the briny waves of such a sea, some of the iron present might temporarily dissolve as ferrous sulphate, accounting for the frequent red colour of rock-salt. Any sulphur combined with the iron would be oxidized to sulphuric acid, and go to augment the gypsum

derived from the sea-water by combining with lime from the surrounding strata, while the crumbled trap, subsiding as clay, and becoming interstratified with gypsum, would wrap up the salt in a protective covering, and preserve it from re-solution.

Another noticeable and not easily accounted for feature in the geology of rock-salt is its frequent association with bitumen and petroleum, which are found with salt in the oil formations of Pennsylvania and elsewhere. Bastennes, where bitumen was long worked, is close to the salt deposits of Dax, at the foot of the Pyrenees; and petroleum floats in small quantity on the surface of a spring near Orthèz, and has been found in a boring in the neighbourhood of Salies, in the same district. Petroleum and bitumen also occur not far from Volterra, in Tuscany, where the largest rock-salt works of Italy exist, and near to which are Count Larderel's celebrated boracic acid springs; and they are worked in some quantities in Wallachia, where also much rock-salt is found. Petroleum has lately been discovered in Hanover, not far from the German salt deposits already mentioned. Bitumen colours the lowest beds of the rock-salt mines of Nancy. It is found in and around the Dead Sea in numerous places, while both bitumen and petroleum occur abundantly at Baku, on the Caspian, near some large salt deposits both old and recent. A good deal of organic matter, both vegetable and animal, exists in the sea, and as its waters become concentrated, such organic matter would concentrate with them. Such facts testify strongly to the theory that rock-salt is a true sedimentary rock, and that it probably owes its origin to the slow evaporation, in the course of enormous lapses of time, of salt lakes or inland seas fed from the waters of the ocean. The sea as it now exists may owe some of its saltness to the solution of rock-salt formed during previous geological periods, and subsequently depressed beneath the present ocean. Probably such cases of solidification and re-solution have been frequently repeated, but that the present known formations

of rock-salt owe their origin to an evaporation of salt-water, such as is now going on in certain quarters of the globe, as for instance, on the shores of the Caspian Sea, rather than to any eruptive agency, there can be hardly any room to doubt.

Taking a detailed but hasty glance at the salt supply of the world, we find that Europe is well provided with deposits of rock-salt and brine-springs. The Carpathian district is the richest and most extensive, and it is calculated that its deposits of salt would alone be sufficient for the supply of the whole continent for several thousand years. This district may be divided into the Moldo-Wallachian, Transylvanian, Galician, and Hungarian sections. The salt-mines of Wallachia are very noted, and the salt is distributed by means of the Danube and its tributaries, over a very large district. The salt used is the rock-salt, as is generally the case throughout the district of the Carpathians. Owing to the absence of cheap fuel, and the tolerable purity of the rock-salt, very few attempts to manufacture white salt have been made, and millions of gallons of nearly "saturated" brine are allowed to run to waste. Transylvania is richer in rock-salt than any other portion of Europe. It consists of a central basin, that of the Maros river, and the basins of the upper courses of the Számos and Alt rivers. The whole territory is more or less mountainous, and the deposits of rock-salt are frequently found along the banks of the small rivers amongst the hills. The supply of salt is inexhaustible. The great centres of salt-mining are Máros Ujvar, on the Máros river, most favourably situated for water communication, and hence the largest shipping town in the district, exporting seventy per cent. of the Transylvanian salt. The Galician district extends along the North and North-east slopes of the Carpathians, from Moldavia to Moravia. There are numerous mines and brine-springs scattered at intervals along this district. The most celebreted salt-mines in the world, and those longest worked, are the mines of Wieliczka and Bochnia, at the extreme west of Galicia.

Together they produce annually 45,000 tons of salt. The mines at Wieliczka have been worked since the 13th century. The Hungarian salt district is very extensive, but almost wholly confined to the region of the Carpathians, from the borders of Transylvania to Moravia. One of the largest tracts lies in the basin of the Számos, in the neighbourhoods of Szathmar and Szigeth, and in the neighbouring districts of Marmaros. In the localities of Soovar and Szlec, in the extreme north of Hungary, there are numerous mines.

The district of the Austrian and Bavarian Alps is probably the best known salt district of Europe to ordinary travellers. The most important mines and springs lie in a comparatively small area, in the upper parts of the basins of the Traun and Salza, and partially in the basin of the Inn. The most celebrated region is the Salzkammergut, lying on both sides of the river Traun, on the borders of Styria and Salzburg. The salt is chiefly manufactured. In many cases, water is allowed to run into the rock-salt mines, and to become saturated brine, then drained off, and manufactured, many miles away. The district extends into Bavaria, along the valley of the Salza. The most important salt towns in the Austrian portion are Aussee, Ischl, Hallstätt and Hallein. The Bavarian portion is very rich in salt, the chief towns being Berchtesgaden, Reichenhall, Traunstein and Rosenheim. The last-named manufactures the salt from brine conveyed in pipes from Reichenhall. This Alpine district extends into the Tyrol. At Hall, near Innsbrück, in the Inn valley, are very extensive salt deposits and salt-works, and the rocks are similar in character to those of the Salza and Traun. In Austro-Hungary the rock-salt is generally retailed in lumps, but some is ground and sold in that form at the shops in towns. Its price differs in various parts of the kingdom, according to the distance from the centres of its production, varying from 1d. per lb. near the mines, to 1½d. per lb. at distances from them. In both parts of the Empire the salt trade is a government monopoly, producing

in Austria a profit of two millions sterling of our money, and in Hungary a million and a quarter. A considerable quantity of Austro-Hungarian salt is sent into Italy, where salt is dear in consequence of the duties laid upon it.

In Germany there are a very large number of salt-mines and brine-springs extending from Segeberg, in Holstein, in the North, to Sulz, on the Neckar, in Würtemberg, on the south, and from Kreuznach on the Nahe, on the west, to Halle near Magdeburg, on the east. The district between the Elbe and Weser contains very large quantities of salt, and springs of brine are met with in great numbers, from the banks of the Werra and Saale, to those of the Aller. The most numerous springs, as also the rock-salt deposits, lie near the various small ranges of mountains that are scattered about the district, as the Thuringer Wald, Harz Mountains, Tentoberger Wald, &c. Two localities of special importance are the district between Magdeburg and Halle, more especially in the neighbourhood of Stassfurt ; and the Luneberg Heath in Hanover, to the south of Hamburg. In both localities brine-springs have long been known, and Schönebeck and Luneberg have been centres of salt manufacture for a considerable period.

The Vosges district is a very important one. Its salt meets English salt very extensively in Belgium. Great portions of East, North, and Central France are supplied from it. Until the late Franco-German war, the district belonged wholly to France, but lying in the ceded district of Alsace-Lorraine (principally in Lorraine), now belongs to Germany, thus rendering Germany the possessor of some of the most extensive salt deposits in Europe. The salt is chiefly manufactured from brine-springs, though a considerable quantity of rock-salt is mined at Vic, and at Varengeville, near Nancy.

Since France has lost the salt district of the Vosges, the long-noted one of the Jura has become of more importance. It is separated from that just mentioned by the Plateau of Langres, and lies in the basin of the Saône and Doubs. The salt-springs of Salins have been noted from remote

antiquity. The chief centres of manufacture are Salins, Arc, Lous le Saulnier, Montmorot, and Saulnot.

In Switzerland a small salt district lies on the right bank of the Rhone, just before the river enters the Lake of Geneva, in the Canton de Vaud. It has rock-salt mines and brine-springs. The chief centres are Aigle, Bex, and Roche. Rock-salt was mined here 300 years ago.

Like the Carpathians, the Pyrenees are rich in rock-salt deposits and brine-springs. In the west district of the Pyrenees, in both France and Spain, salt appears to be most plentiful. In France, the basin of the Adour is the most important district, and contains the towns of Salies de Béarn, Briscous, and Villefranche. At Salis d'Arbas, on the Garonne, near the Pyrenees, a brine-spring exists, and salt is manufactured. In Spain, the whole basin of the Ebro is rich in salt, especially towards the source of the river, as is indicated by the number of villages named either *sal* or *salinas*. In one small district, are Salinas, Salinas d' Amana, Salinillas, and Poza de la Sal. On the banks of the Ebro, are Mendavia, Valtierra, Remolinos, and Sastag. Both rock-salt and brine-springs are plentiful. One of the most peculiar deposits of rock-salt known to exist is in this district, about 45 miles N.-W. of Barcelona, on the banks of the Cardona river. This is the famous rock-salt mountain of Cardona, a hill composed entirely of rock-salt, which is worked in open quarries like stone. There are indications of salt in various other places; and indeed Spain seems richly endowed with this mineral.

Some other more or less isolated salt-deposits and brine springs may also be mentioned. For instance, in France, at the foot of the Alps, at Moutiers and Castellane, are well-known brine springs from which salt is made. In Italy, at Volterra, in Tuscany, salt is manufactured; and at Lungro and Altamonte, in the Mountains of Calabria, rock-salt is mined. In Sicily, at Nicosia and Mussomeli, are salt deposits. At Számobor, in Croatia, and Tuzla, in Bosnia, salt is found. In Russia, at Bachmutz, on the Donetz; Balachna, on the Volga; Staraia Russa, near Lake

Ilmen; Solikamsk, on the Kama; and at Hetzkaya, salt deposits exist. At Eupatoria, in the Crimea, rock-salt is found. In Prussia, at Jnowraclaw, Rawicz, Waltersdorf, brine-springs exist; and at Sperenberg, South of Berlin, a bed of rock-salt, of the enormous thickness of 2810 ft. was bored into in 1870.

Deposits of rock-salt have not hitherto been discovered in the United States of America, although their presence seems to be indicated by numerous salt-springs. In the central States these springs are very common, particularly in Arkansas, Virginia, Ohio, and Kentucky, and also in Pennsylvania and New York. Throughout North America the term *Lick* is applied to those marshy swamps where saline springs break out, and which are frequented by deer, buffaloes, and other wild animals for the sake of the salt, whether dissolved in the water, or thrown down by evaporation in the summer season, so as to encrust the surface of the marsh. Cattle and wild beasts devour this incrustation greedily, and burrow in the clay impregnated with salt in order to lick the mud. The manufacture of salt from brine is carried on mainly after the method pursued in our own salt districts, which will be described in Chapter IV.; the brine being mostly obtained by boring where there are indications of salt. A similar remark applies to Canada. But North America will probably look to us for its main supply of the best table salt for some years to come.

Rock-salt is found in different parts of South America.

Looking further a-field we find numerous lakes of salt-water in the steppes of Asiatic Russia, Lake Inder alone containing such an abundant supply of salt of the first quality, that it would suffice for the consumption of "all the Russias," if the difficulties attending the carriage were not almost insurmountable. China, like North America, bores for brine, of which it seems to have a fair supply. In the province of Szu-Tchhouan, on the borders of Thibet, occur a number of salt-wells with the remarkable accompaniment of springs of inflammable gas; so that nature not only

furnishes the brine, but also the fuel for evaporating the water and extracting the salt. There are several other wells of the same nature in the different districts of this department of Kia-Ling-Fou, and in the other neighbouring districts, situated to the east of the great chain of mountains covered with perpetual snow, which traverses the eastern part of Szu-Tchhouan, from south to north. But of all the countries in Asia, Persia is the most abundantly supplied. All the lakes are salt, and every considerable collection of water is impregnated with it. Salt-mines also are found in different parts, and salt-deserts are a striking feature of Persian scenery. There are salt-mines in Morocco, but the product is of a red colour, very strong and coarse. The lakes of Barbary are almost all as salt as the sea, and in the course of the summer may dry up entirely, leaving the mineral incrusted on their beds: and near the lake of Marks, in the Algerine territory, is a mountain composed entirely of salt. Salt-water lakes abound also in Southern Africa.

British India, considering its vast extent, can hardly be said to be well supplied with what may be called inland salt. The bulk of this is obtained from the evaporation of the water from the Sambhur Lake, and from the Punjaub Rock-salt mountains. This extensive range of mountains stretches from the base of the Suliman mountains in Afghanistan, in an easterly direction, to the river Jailum in the Punjaub. It is known to the natives in different parts by many different names; but among Europeans it has acquired the general term of Salt-range, from the great extent and thickness of the beds of common salt which it in many places contains. One is 200 feet thick, and the salt varies in colour from white to flesh-colour and brick-red. In addition to the supply from these sources, salt, from the evaporation of sea-water, is obtained along thousands of miles of coast. But India, like North America, will take large supplies of salt from us for some time to come, and probably in increasing quantities; some remarks on which branch of our salt trade will be found in Chapter VI.

Some remarks also on the production of salt from sea water will be found in Chapter V.

We now come to the English salt-producing districts, which though very prolific, are of limited extent: but, as these and their salt production will be treated of in the following chapters it will suffice here merely to mention the chief centres of rock-salt and brine-springs in this country. These are Northwich, Middlewich, Winsford, and Sandbach, in Cheshire, the basins of the rivers Weaver and Wheeloch mainly forming the salt district; Stoke Prior and Droitwich, in Worcestershire; to which may be added Weston-on-Trent in Staffordshire. At Duncrue, near Carrickfergus, in Ireland, there is an important rock-salt deposit. At Middlesborough-on-Tees,' another valuable deposit of rock-salt exists, and at Chester-le-Street, in Durham, is a brine-spring. Indications of salt are also to be met with in Shropshire and Lincolnshire.

It is probable that the production of salt will be still further developed at the centres in Ireland, Yorkshire, and Durham just above mentioned. It was not till as recently as 1851 that rock-salt was discovered at Duncrue, when a trial shaft was being sunk in the hope of finding coal on the Marquis of Downshire's estate. Consequent upon this discovery new shafts were sunk by the Belfast Mining Company and Mr. Dalway, and the deposits have been worked ever since. Another "Winning" was commenced in 1884. Some statistics in reference to the production of Irish rock-salt will be found in Chapter VI.

The rock-salt deposit at Middlesborough was only discovered in 1862, when Mr. John Vaughan, of Bolckow and Vaughan, bored for water on the south bank of the Tees, for feeding his steam boilers, and struck the salt at a depth of 1,200 feet. The firm subsequently endeavoured to work the deposit by means of a shaft, but soon abandoned it on account of the heavy cost. In 1874 Messrs. Bell Brothers sank a bore-hole on the north side of the river, and found the salt at a depth of 1,127 feet, or 73 feet nearer the surface. This deposit exists in the palæozoic series,

overlying the coal measures, and is about 3,000 feet lower, and considerably older, geologically, than the Cheshire salt, which is found entirely in the triassic series of rocks. The theory of its formation is that the salt water, in isolated basins cut off from the sea, or communicating with it by narrow entrances only, was gradually concentrated, until it became saturated. The extent of the bed has not been ascertained ; and all that is known at present is that it rises to the north and dips to the south. The thickness, however, as proved by a second bore-hole put down by Messrs. Bell in 1881, is 65 feet, warrants the estimate that salt is present under Middlesborough in the proportion of 200,000 tons to the acre. In Cheshire the surface water trickles through the clay to the gypsum, and flows over the salt, which is thus converted into brine, and only requires being raised to the surface ; but in the Middlesborough deposit the nature of the strata and the great depth preclude all chance of infiltration. It occurred, however, to Mr. Thomas Bell that the salt might be raised by allowing fresh water to flow into the hole and become saturated with salt, and then pumping out the brine, without sinking a shaft. Accordingly, the bore-hole was put down successfully by the rotary diamond drill ; and it so happened that a portion of the lowest core was left at the bottom of the hole, leaving an annular space, which has served to receive the lower end of the lining tube. This latter is perforated with holes where it passes through the salt ; and the greater portion of its weight is carried by a ring resting on the surface. An inner tube, perforated fcr a short distance at the bottom, is supported partly by a plate at the bottom and partly by girders at the top. There is an annular space between the two tubes, into which fresh water is allowed to flow. This water makes its way out through the holes in the outer tube, becomes saturated with salt, and rises in the inner tube, but only to such a level that the two columns bear the proportion of ten to twelve, that being the relation of the specific gravities of brine and water. The pump is, however, placed below this level, so as

to avoid the necessity for suction. The pump, worked by an engine at the rate of 14 strokes a minute, lifts from 8 to 9 gallons of brine at each stroke. When the cavity in the salt bed at the bottom of the hole has attained a certain size, the following is supposed by Mr. T. Hugh Bell to be what takes place. A molecule of water, descending the annular space between the two tubes, reaches the upper cavity in the salt, and there finds saturated brine. It, therefore, no longer continues its downward course, but floats on the surface of the heavier fluid, having no tendency to sink until it becomes saturated by coming into contact with the undissolved rock-salt. The cavity at the bottom is, therefore, filled with a solution of salt, saturated, or nearly so, with fresh water flowing along its surface, and which gradually becomes saturated in turn. The pump draws the saturated solution from the bottom of the hole, and makes room for fresh water on the surface, so that there is a tendency for the hole to become enlarged at the bottom, and assume the form of a very flat inverted funnel. The brine is pumped into a reservoir containing 500,000 gallons, and, roughly, between 500 and 600 tons of salt, the salometer standing at about 23°. Thence it flows into twelve shallow evaporating pans, nine of which are heated with coal, and three by the waste gases of the blast-furnaces adjoining, the temperature of the brine being kept at 170°. The salt crystallises in regular cubes, which float on the surface; and on each cube is formed others, until the whole mass becomes too heavy to float, and sinks to the bottom. Some difficulty was experienced in a thin pellicle forming on the surface, which prevented the crystals from falling, and also arrested evaporation. This was found, on investigation, to be due to gelatinous vegetable matter, which was present in the surface water used; but upon water from the Darlington Waterworks being substituted, the difficulty ceased. Salt is taken out every other day upon platforms, called "hurdles" between the pans, and conveyed in barrows to railway waggons. A scale of sulphate of lime forms on the bottom of the pans, which requires removing at intervals,

and also necessitates the laying off and thorough cleaning of the pans every three or four weeks. The twelve pans some time ago produced 360 tons a-week of coarse salt suitable for curing purposes and for chemical works, table salt requiring to be crystallised at a much higher temperature. The firm are now turning their attention to the utilisation of the brine, as it comes from the bore-hole, for making carbonate of soda. They are also making preparations for putting down another hole, to be ready in the event of the existing one failing, through a fall of the roof, or the tube being destroyed.

The utilization of the large deposits of salt that have been known for twenty years to exist in South Durham has been for some time in progress. The brine from the bore-holes has been converted into salt, large quantities of which have been sent to some of the alkali works on the river Tyne. It has been sold at rates as high as that from Cheshire; so that, when the difference between the cost of carriage is borne in mind, the price of the South Durham salt must be profitable to its producers. It is impossible as yet to state what the effects of the utilisation of these deposits will be, as they are believed to extend from Middlesborough under the river Tees, to somewhere not far from West Hartlepool. If anticipations be realized there will be a great change in the position of the Tyne chemical trade. It will ultimately obtain cheap salt, and it is probable that on the low-lying and not fertile shore between the Tees and West Hartlepool large chemical works will be soon erected.

CHAPTER III.

ROCK-SALT, AND BRINE IN THE ENGLISH SALT DISTRICTS.

SALT was produced from the brine-springs in the Cheshire and Worcestershire salt districts at a very early period of our history, and it would seem that all places where such springs or brine-pits existed, were called by the name of *Wich*, a termination that still distinguishes most of the salt towns at the present time. The name Droitwich, it seems, was originally *Wich*, and it is supposed that the prefix *Droit* was given to designate a certain legal or allowed brine-pit. Some of the earliest records of the brine-springs relate to those of Droitwich. It appears that in the year 816 Kenulph, King of the Mercians, gave Hamilton and ten houses in Wich, with salt-furnaces, to the church of Worcester; and about 906, Edwy, King of England, endowed the same church with Fepstone and five salt-furnaces, or scales. William the Conqueror caused an inquiry to be made into the names of the several places, and by whom they had been held in the time of Edward the Confessor, and found the Wiches and salt-houses then in operation recorded. Henry III. caused the brine-springs to be destroyed, to prevent the Welsh, with whom he was at war, from getting supplies of salt. Later on there were 216 salt-houses at Nantwich. In 1671 it appears that at Winsford two salt-works were in operation, and in 1808 Dr. Holland described the brine-springs of Cheshire. In Staffordshire, also at Shirleywich and Weston-upon-Trent, salt was made from brine in early times.

Salt is obtained either in a solid state from rock-salt mines, or from the evaporation of the water from the brine-pits or springs; and though the latter have been worked from the earliest periods in the history of this country (part

of the pay of the Roman soldiers being in salt, giving rise to the word *salarium*, "salary"), the deposits of fossil or rock-salt were not discovered till the year 1670, when in the process of searching for coal in Marbury, about a mile to the north of Northwich, a stratum of rock-salt was hit upon, about thirty yards thick, and about thirty-four yards below the surface of the ground. In 1779, rock-salt was discovered near Lawton in three strata, with beds of indurated clay between them, the lowest stratum producing the purest salt. The Marstone mine at Northwich is the largest in the kingdom; and in 1781 its owners instituted lower sinkings, which resulted in what is now known as the "bottom of the bed" of rock-salt. The old shaft by which the bottom bed was thus proved still remains, and the workings that were made from it in the bottom bed still form a part of the present Marston mine; but the work at the bottom mine has long been carried on by shafts sunk direct from the surface. The depth to the floor of the bottom bed is 110 yards at Northwich, and at Winsford, a few miles distant, 159 yards. The two beds of rock-salt in the Marston mine are each from 28 to 30 yards in thickness. Further explorations show that more rock-salt lies below what is called the bottom bed, but it is in thin strata and irregular masses, none of which have yet been worked. The sites of most, if not the whole, of the old rock-salt pits appear to be known, and about 40 old workings are now closed. The rock-salt pits now open in the United Kingdom are about twenty-five. So thoroughly free from all moisture have the rock-salt deposits become, that chemical analysis proves that there is absolutely no water at all contained in them, while one or two parts out of every hundred are found in the driest salt made from brine.

A winning, as it is called, for working rock-salt as now sunk, consists of two shafts, placed from 10 to 15 yards apart, with another for pumping the surface water, which is sunk only as deep as the water penetrates. A few of the winding shafts are made wide enough for two ropes,

and are fitted with conductors; but most of them, at the part which is cased to keep back the fresh water and brine, are only about 3½ feet in diameter, and as the buckets used for drawing with are nearly as wide, they rub against the sides. One of the earliest precautions found requisite in the rock-salt shafts, and afterwards in brine-shafts when they came to be sunk through rock-salt, was the necessity for protecting the rock-salt at the sides from being dissolved by fresh water. Consequently, all shafts going from the surface into rock-salt are turreted or roofed over to keep out rain and snow, and are carefully cased down to a solid foundation, below where surface water penetrates into the ground. In olden times the casing seems to have been made of wood, but recently this has been substituted by iron. Cast-iron tubing for the shaft casing was introduced into the rock-salt mines of Northwich by Mr. Arthur Anderson, senior, about the year 1845. The construction of it is similar to what had long been used in colliery shafts, when it was originally cast in complete cylinders, instead of segments, as introduced by the late Mr. John Buddle. The space behind the cylinders is filled with cement to make all as close as possible. It was supposed that what the wood casing failed to do, would be effectually accomplished by these iron cylinders, and in most instances, when they have been properly secured through the top bed of rock-salt, and properly "based" at the bottom, this has been effected. However, notwithstanding the greatest care in putting in the castings, fresh water sometimes finds a passage behind them, which, if not discovered and speedily stopped, soon dissolves the rock-salt, so that the wedging ring and cylinders slip, and the shaft collapses. In the present bottom bed workings, the height of rock-salt varies from 15 to 18 feet in Cheshire.

The rock-salt is obtained in masses of considerable size by the usual operation of blasting, and with the aid of mechanical instruments. The drills used for drilling the shot-holes are about 8 feet in length, pointed at each end, and larger in diameter in the middle, for handling, no hammer

being used. In charging the shot, the fine rock-salt made in drilling the hole is put next the powder, and the coarser grained upon that. Safety fuse is very seldom used. The charge is fired by a straw filled with fine powder, which is lighted up by a piece of candle-wick. In firing the shots, the men retire only a few yards, but as the rock-salt does not usually fly far from the shots, and as it will not strike a light either with iron or steel, accidents with powder are much fewer than might be supposed. The winding is now done entirely by steam engines; and iron tramroads are used, though instead of sleepers, the rails are often fixed to pegs let into drill-holes in the rock-salt. The two winding shafts are open to each other in the same chamber at the bottom, without any separation for ventilation, as practised in other mines. The ventilation, notwithstanding the smallness of the shafts, and the want of ventilating power and partitions for sending the air round the workings, is usually good, except for about two months in the hottest part of the summer. At that time the air, it appears, becomes stagnant, and it is said that the miners, when they used to stay in it, got headaches, and their clothes smelled of stale powder smoke. This continues until the cold weather sets in, when the pits again begin to draw freely, and the bad air, as it comes out, may be inhaled in the adjoining lanes. In a general way, the rock-salt strata are remarkably free from carbonic acid gas, and in only one instance at Northwich, and another at Meadow Bank, Winsford, does fire-damp appear to have been met with, and even then in very small quantity. The workmen look healthy; and as a proof of the usual purity and coolness of the air, butcher's meat will keep good in the mine for weeks even in the hottest time in summer.

The system of working the mines appears to have varied very little since the beginning, but the size of the pillars of salt which support the roof and distances between them has been a moot point. Thus "roofing" is a most important matter. An old plan, dated 1786, is in existence showing the top and bottom workings of the Marston mine, as

they existed at that time. The size of the pillars in the top bed is about 6 yards by 4, and in the bottom bed (which was then only being commenced) the shaft pillars were set out from 10 to 12 yards in width. The workings in the bottom bed at the Marston mine are now the most extensive in Cheshire. They are in an oval form, 640 yards long by 820 broad, extending over about 36 statute acres. There are altogether 131 pillars in the mine. The height of each pillar is about 5 yards, and they are of various breadths, lengths, and distances apart. Several are 8 or 9 yards square and 25 yards apart, which seems scarcely sufficient, as some of these are cracked at the corners. The more recent ones are 10 yards square, and 25 yards apart. The thickness of the strata which they have to support from the base to the surface, is about 110 yards. At Mr. Dalway's mine, on the dip of the Duncrue mine, at a depth of 295 yards, which at present is the deepest mine in the United Kingdom, and where 40 feet of rock-salt is being worked, the pillars are 12 yards by 10 at the top, widening to 14 yards by 12 at the bottom. It remains to be proved how the roof will stand with this height of working and consequent reduced thickness of rock-salt left for the roof. The greatest distance now to be seen of the roof of any rock-salt standing without intermediate support is the 43 yards in Platt's Hill mine. It would appear that at 110 yards from the surface, with a thickness of 22 yards of rock-salt left above the pillars, a width of 25 yards is found to stand secure, and the proportion of 10 yards by 10, equal to 100 square yards for each pillar left in each area of 35 yards by 35, equal to 1225 square yards (being in the proportion of one pillar to every 12¼ excavated), is usually found enough to stand without crushing. Pillars 8 yards square and 25 apart, being in proportion of only about one part left for each 17 parts excavated, have been found to stand, where the workings are narrow and the roof derives support from the boundary ribs; but for a large area of workings, this proportion seems inadequate. "Crushing" begins usually

by cracks or breaks at the corners of the pillars. Even in this state the salt generally adheres together, but the roof "creeps" nearer the floor, and the parts of the shafts which are in rock-salt becomes smaller in diameter. In three mines worked about thirty-five years ago, the roof of the bottom bed did not adhere, but fell in. When the working of rock-salt in Cheshire became extended to the bottom bed, and the top bed was discontinued, the pillars in the bottom workings seem to have been made without regard to placing them under those in the top workings.

In the year 1872 the Japanese ambassadors and their suite, accompanied by several leading members of the Salt Chamber of Commerce, paid a visit to the Marston mine. The occasion was most interesting, and the ambassadors, in a document to which was appended their signatures, expressed themselves highly delighted at what they had seen and learnt. Occasionally as many as a thousand persons from Manchester and other manufacturing centres make an excursion to the salt district of Cheshire and descend a mine, thoroughly illuminated for the occasion, long "streets" being fitted up with stalls and refreshment bars. Music is also plentifully supplied, and as many as 400 persons have been known to join in one dance in these crystal halls.

The rock-salt produced in this country is mostly exported to Belgium and other parts of the Continent, the greater portion of it in lumps, but some crushed according to the purposes for which it is required. Germany used to take some rock-salt from England, but her discoveries at home have caused this trade to diminish. Some consumption of ground rock-salt has sprung up of late, for use in the Hargreaves process of making "salt-cake," for which it is better suited than common salt.

The "pits" from which the brine is obtained for the manufacture of white salt by evaporation are of two kinds, namely, the "springs" which come from the top of the rock-salt, or as it is locally termed, the "rock-head,"

old rock-salt mines which have become inundated, and in which the water is consequently saturated. It is quite impossible to obtain any list of the ancient brine-pits ever discovered, but of known brine-pits now closed there are over seventy, perhaps even one hundred, in the United Kingdom. The number of those at present worked including "rock-head" brine and old rock-salt pits, is over fifty. In Camden's time, the method of raising the brine was by human labour. He says, "At Northwich there is a deep and plentiful brine-pit, with stairs about it, by which, when the people have drawn the water in their leathern buckets, they ascend half-naked to these troughs and fill them, from whence it is conveyed to the wich-houses." Hand-pumps were afterwards used, and in a few situations which admitted of the assistance of a stream of water, a water-wheel was employed; then horse power and afterwards windmills were introduced; but subsequently steam power superseded all other methods, as the demand for salt increased. The pumping is done through shafts, in the sinking and securing of which the precautions requisite are identical to those required in the rock-salt pits, and having been earlier in point of time, the necessities appear to have been met as they arose. It seems that in sinking to many of the springs, the supply of brine when cut into was so copious that the sinkers had to escape for their lives, sometimes rising up the shaft amongst the brine without any opportunity being afforded of seeing what was underneath; a fact which accounts for the lateness of the discovery of the rock-salt. In those sinkings where it is still unknown at what depth the brine is likely to be met with, there seems to be no entire remedy against these sudden irruptions. But in the "proved" districts, it is now observed that before reaching the top of the rock-salt, when the rock-head brine flows, there is often a bed of hard marlstone called "the flag," and that for a few feet above it the marl is of a granular structure called "horsebeans." When these indications are observed, and the brine is expected to

be found at a high pressure, the practice is to case the shaft sides carefully down to the flag, to keep the sides secure and prevent surface water from entering. The flag is then either blown through with powder, or bored through with boring rods. The depth from the surface at which the brine-springs are found, the level they take when the stratum which immediately confines them is penetrated, and the abundance of the springs are very various. In Cheshire, in 1808, according to Dr. Holland, the brine at Nantwich was met with about 10 or 12 yards from the surface, and it was difficult to avoid brine in sinkings for fresh water. The brine when reached rose nearly to the surface. At Winsford, it was about 55 to 60 yards before it was met with, and when found it was in great abundance, and it rose to within 12 yards from the surface. At Northwich, it was likewise very abundant, and was found at from 30 to 40 yards. At Winsford at the present time it is met with at the same depth as before, and is still very copious, but the pumping being greatly increased, it now only rises to between 39 and 46 yards from the surface, except on Sundays, when the pumping in many shafts is stopped. The average level is being lowered at the rate of about 1 foot annually; and when it is at the lowest, some of the shafts are dry. At Northwich, the depth where it is now met is about 44 yards below the canal level, and it is kept down by pumping to nearly that depth. At Wheelock, the deepest shaft is 88 yards, and bored 6 yards below that, and the level to which the brine rises is between 30 and 35 yards from the surface. At Middlewich, the deepest pit is now 90 yards. The level which the brine takes in some of the pits varies between 25 and 70 yards from the surface. A daily record has been kept by Mr. H. E. Falk, of the Meadowbank Spring at Winsford, which shows that at the beginning of each week, when most of the pumping has been stopped for some hours, the level is higher. In Staffordshire, the brine at Shirleywich in 1808 appears to have been abundant, but weak; and it is still apparently

the same. The level to which the brine rises, when not kept down by pumping, is 12 yards from the surface. In Worcestershire, at Droitwich, the brine is still copious and strong, and when it is not kept down by pumping, it rises to the surface. The Droitwich Salt Company's shafts are 26 yards 2 feet, and bored to 70 yards. At Stoke Prior, with the present pumping, the brine rises to 65 yards from the surface, and it is not apparently lowered by pumping.

CHAPTER IV.

THE MANUFACTURE OF WHITE SALT FROM BRINE.

THE different kinds of white salt produced from brine are, according to the terms of commerce, first divided into two classes, the "boiled" and the "not boiled." The boiled salt is the "fine" salt we use as a condiment, and is also called "lump" or "stoved lump" salt, the other varieties of "boiled" salt are "superfine stoved;" butter salt, not stoved; and cheese salt, not stoved.

The "not boiled" salt comprises what are called "common" salt, the various fishery salts, and bay salt; but our main concern here is with the "fine" salt, or table salt as we may call it.

The manufacture of white salt from brine by the process of evaporation caused by heat, the brine during the process being "agitated," is the chief business of the salt manufacturers in this country, and it is by far the most important of all the methods by which salt is prepared, so far as England is concerned, for not only is the salt thus obtained in a far purer condition than by any other method, but by this method we alone produce in the Cheshire and Worcestershire salt-works, probably as much as a third of the quantity of salt which is consumed in the whole of Europe.

In the time of Edward the Confessor, brine-pits as previously noticed, were wrought at all the *wiches* in Cheshire; but at that period, and for several centuries later, the art of making salt seems to have been very imperfectly understood, and the quantity was inconsiderable. Henry VI., being informed that a new and more productive method had been invented in the Low Countries, invited John de Sheidame, a gentleman of

Zetland, with sixty persons in his company to come and instruct his subjects, promising them protection and encouragement. The result is not stated; but it does not seem to have been successful, for we find the Royal Society, soon after its constitution, directing its attention to the improvement of the art of manufacturing white salt, and publishing several new methods, or rather reports of the methods then in use than suggestions or improvements. The salt made in England was still considered inferior to foreign salt; and that which was manufactured in Cheshire was confined to the supply of its own consumption and that of a few neighbouring counties. About the commencement of the last century, the attention of the House of Commons was directed to the supposed inferiority of the English manufacture; and a reward was granted to Mr. Lowndes, a Cheshire gentleman, for certain improvements made by him. In 1748, Dr. Brownrigg published a treatise on the *Art of Making Common Salt*. Some of the improvements suggested by him were adopted with good effect, and others were engrafted on them. The river Weaver was also made navigable for vessels of considerable burthen from Northwich and Winsford to Liverpool, whereby the facilities for distributing Cheshire salt became greatly increased; the manufacture gradually rose into importance, and salt was not only distributed over the country from this source, but considerable quantities were exported.

The process of evaporating brine is on the whole very simple; and though many attempts have been made to introduce more scientific methods, and numerous patents have from time to time been taken out for this end, the long-established plan of evaporating the water from the brine in large shallow pans by means of heat applied below them is still in vogue; nor does it seem likely that it will be superseded. The brine, on being pumped from the pits, is run into large cisterns, or into reservoirs made sufficiently high for it to flow by gravitation through pipes, as it is required, into the evaporating pans. It is then evaporated upon one general principle. The heat is usually supplied

from coal fires underneath, but sometimes the spare heat from a steam-boiler or the discharged steam from an engine is used; and occasionally there are pipes with steam in them, amongst the brine in the pans. In this way, according to the degrees of heat, the product is small or large grained salt; the simple rule being, that the greater the heat employed and the less time in the pan, the finer the salt made, while the less heat and the longer the time in the pan, the coarser the salt. For what is called "lumped," or "fine-grained," i.e. our ordinary table salt, the brine in the pan is brought to a temperature of 226° F., which is the boiling point for brine. Crystals soon form on the surface, and after skimming about a little, they subside to the bottom. Each crystal appears granular or a little flaky, and is in the form of a small quadrangular, though irregular, pyramid. For "common" salt, as it is commercially called, the temperature is 160° to 170°. The salt thus formed is close in texture and clustered together in larger or smaller pyramids according to the heat applied. For large-grained flaky salt the temperature is 130° to 140°; for large-grained fishing salt 100° to 110°, the slowness of the evaporation allowing the salt to form in cubical crystals, although it appears that they are not perfect cubes. What used to be called "bay-salt," or salt formed by the operation of the air and heat of the sun, seems now to be a thing of the past, so far at least as the salt districts are concerned, although varieties are manufactured to suit the fancy of purchasers. To produce these kinds, foreign matters supposed to be of a harmless kind, such as the white of eggs, calves' and cows' feet, ale, flour, resin, butter, alum, etc., have been added to the brine for clarifying and to promote crystallization. The finest salts are drawn from the pans twice or three times in the 24 hours. If allowed to remain too long, the salt crystals would increase in size, and the thick layer of salt on the bottom of the pan would prevent the heat reaching the brine sufficiently to keep it boiling. For "drawing" the salt, it is brought to the side of the pan by

a scraper or rake, and then taken out by a long, flat, perforated iron instrument; for it must be remembered that the brine, as fast as it evaporates, is replaced by more, so that the pan is always nearly full, and thus it is necessary to let the brine drain out of the salt.

Fine salt, as taken wet from the pans, is generally put into "tubs" or moulds which are placed at the edge of the pans, their shape being that of the lumps of salt seen in our shop windows, or hawked about the streets. Eight of these tubs of 14 lb. each make the cwt. At the manufactories it remains in the moulds till the water drains off and it attains consistency enough to be handled, which is the case in about half an hour. It is then turned out and carried into the stove which is at the back of the pan, and is formed by continuing the flues and bricking them over, having the chimney at the far end. The lumps remain till perfectly dried through (known by their giving a clear ringing sound when struck), and then go to a store room above the stove, which receives heat from it. The lumps are then ready either for sending out as stoved lumps for household and other purposes, or for breaking up and filling into sacks for exportation, especially for America, for which country it is often ground finer in mills before being packed. Sometimes the fine salt is not stoved at all, nor yet made into lumps, and is then generally known as butter salt. The largest kind of salt is sometimes allowed nearly a fortnight for formation in the pans. The natural form of the crystals is a perfect cube, unless the formation is interrupted by agitation or strong heat. These cubes exhibit diagonal striæ, and frequently on each side produce squares parallel to the external surface. Every cube is formed of six quadrangular hollow pyramids joined by their apices and external surface, and each of these pyramids is filled up by others, similar, but gradually decreasing. By a due degree of evaporation, it is not a difficult matter to obtain these pyramids distinct and separate, or six of such, either hollow or more or less solid, joined together round a centre. Their bases and

altitudes are in general equal (thus showing the disposition of salt to form a cube), and they are composed of four triangles, each formed of threads, parallel to the base. These threads are a series of small cubes. The crystals of salt, formed by natural evaporation of brine from a pool on the floor of a rock-salt mine, are in cubes about half an inch in size, which lie in various positions; but where salt is formed in a rock-salt mine by evaporation of brine trickling through the air, it is in an efflorescent form. The earthy matter contained in the brine is got rid of in the manufacture by its adhering to the pans in the form of scale, called "pan-scale," or "pan-scratch." There is also the chloride of magnesium, called "bittern," which remains in solution after the chloride of sodium (or common salt) is formed. This is often purposely allowed to flow away by having the floor, or the "hurdles" on which the salt is lifted from the pans, lower than the top of the pan. The pans are of various sizes, the only limitation being, that they must not be too wide for a man to draw out the salt with a ladle. Old records show that they were formerly made, at least in Northwich, of lead, but now commonly of wrought iron, three-eighths of an inch in thickness, and about 50 or 60 feet in length, by 24 or 25 feet in breadth and 2 feet in depth; but some of the new pans are 140 feet by 30 feet by 2 feet. Indeed, they seem to have been gradually increasing in size, to which the only limitation is that above mentioned. Until long after historic times wood was the only fuel used, and the large consumption for which purpose seems to have been early complained of, and it was not until the year 1656 that the substitution of coal at Nantwich is mentioned as a novelty.

The following extract from the Report of 1881 on the Salt Districts by Mr. Dickinson, Inspector of Mines, is interesting: "According to Mr. H. E. Falk there has been no improvement in the manufacture of salt since the days of the Romans, and possibly since the days of the Druids, although 400 patents have been in existence, the only difference being that they employed lead pans 10 square

feet, and now iron pans of 1,500 square feet are used; the principle of evaporation is so perfect that there is no room for improvement. Some of the ancient lead pans were, I find, only half the size stated by Mr. Falk. One such, found at Northwich, shown to me by Mr. Ward, being only 2 feet square in the bottom, and 2 feet 3 inches square at the top."

The manufacture of salt from brine is carried on in France and other countries on much the same principles as it is in this.

CHAPTER V.

ANALYSES:—SEA-WATER—SEA-SALT—BRINE—WHITE SALT—ROCK-SALT.

ANALYSES of substances and of manufactured products are generally speaking only of interest and value to a limited class of readers; but some such technicalities must of necessity be included in this little treatise, though it hardly aims at being more than a popular handbook.

The earliest method of artifically obtaining salt was by the exposure of sea-water to the sun and air in shallow pits or reservoirs, the spontaneous evaporation varying much with the general atmospheric conditions. It was at one time practised in this country, for instance at Lymington in Hampshire, at Hayling Island near Portsmouth, at Saltcoats on the Ayrshire coast, and elsewhere, as the remains of old pans still testify. Indeed the evaporation of sea-water for the production of salt in "salterns" or "brine-pans" was formerly one of our staple industries. Since the suppression of the duty on salt, and the development of the production in Cheshire and Worcestershire, the sea-salt industry has been reduced to one or two establishments round the coast where coal is cheap, as at North Shields, where salt is made by artificial evaporation from strong brine produced by dissolving rock-salt to saturation in sea-water. But the employment of solar heat is common in countries where the climate is more suitable. Hundreds of thousands of tons of salt are annually produced in this way along the West shores of France and Portugal, in the Bay of Cadiz, along the East of Spain and South-East of France, and along the coasts of Italy, Austria, Greece, Spain, Portugal, Turkey, Russia, and India. The manufacture of salt from sea-water is in fact

an industry of high importance, employing much labour, and affording large revenues. In some countries sea-water is only evaporated to a certain degree in the shallow pans or reservoirs, and the manufacture is afterwards completed by pouring the brine upon twigs, and sometimes upon burning wood, from which the deposited salt is afterwards collected.

The disuse in this country of the sea-water evaporation process cannot be wondered at when we reflect that the amount of salt in sea-water is very trifling compared with that in well-saturated brine. Though the southern oceans contain more salt than the northern, and some tracts of water more than others, as, for instance, the Atlantic Ocean than the English Channel, speaking in round numbers, salt water contains only a little more than two per cent. of chloride of sodium, as compared with the 25 per cent. contained in good brine; or, to put it in another way, a gallon of salt water contains only ¼ lb. of salt, while a gallon of brine contains from 2 lb. 4 oz. to 2 lb. 10 oz. Then, too, sea-water contains more impurities and much larger quantities of magnesium and potassium salts than brine, and so the production of a pure chloride of sodium involves more complex operations.

Several tables of analyses taken from Spon's *Encyclopædia of the Industrial Arts*, &c., &c., will be found at the end of this chapter. Tables I. and II. refer to sea-water and sea-salt.

As regards the analysis of brine, it seems to have been long noticed that in Cheshire the Northwich brine contained a trace of iron, and that the earthy salts in it were the same which were held in solution by sea-water, being principally chlorided magnesia and sulphate of lime; the proportions of earthy salts to pure chloride of sodium in sea-water being greater than that which prevailed in the brine. An analysis given by Dr. Holland in 1808, which still holds good, shows that the percentage of chloride of sodium and of earthy salts varied in the following proportions in one pint :—

	Oz.	dr.		Per cent.		Per cent.	
Winsford brine	6	1,	or	25·312	of salt, and	2·500	earthy salts.
Leftwich ..	4	15	„	21·250	„	·625	„
Northwich ..	6	1	„	25·312	„	1·562	„
Witton ..	5	7	„	23·125	„	1·562	„
Anderton ..	6	6	„	26·566	„	1·875	„
Wheelock ..	6	0	„	25·000	„	·625	„
Middlewich..	6	2	„	25·625	„	·625	„

Mr. Dickinson, one of Her Majesty's Inspectors of Mines, in his Report of 1881, states that, in his opinion, it is possible that some earthy salts contained in brine may have some connection with the surface drainage, or with the deposits from the use of blasting powder in the rock-salt mines, especially if muddy brine is used. A peculiar odour resembling sewage or stale powder smoke was quite apparent to him when he visited the scene of the great landslip at Northwich in December 1880, and as there can be no question that on such occasions large volumes of surface water find a way into the reservoirs formed by the old mines from which brine is being pumped, sanitary precautions, such as are carefully observed in the working of rock-salt mines, seem equally requisite with respect to the surface water from which such brine is being formed; and that leakage from sewers and foul drains should be avoided.

The brine used in the manufacture of white salt is nearly "*saturated*," i.e. contains as much salt in solution as water is capable of holding. *Fully* saturated brine contains in every 100 lb. about 27 lb. of salt. The best Cheshire brine contains from 25 lb. to 26 lb. per 100 lb. If a brine contains one-fourth of its weight of salt, it is very satisfactory. It is usual amongst manufacturers to estimate the strength of brine by the weight of salt in a gallon; 2 lb. 8 oz. being considered good, and 2 lb. 10 oz. very good. Occasionally it is met with yielding only 2 lb. 4 oz. to the gallon. The importance of strong brine in salt manufacture is evident, when we consider that all the excess of water above saturation point must be evaporated. The excess in cost of making a ton of salt out of 2 lb. 4 oz. brine, as

compared with that out of 2 lb. 8 oz. brine may be stated at 9*d.* per ton; and consequently if competition should be very severe, this would practically shut out the maker with weak brine from the market.

The following are analyses of Cheshire and Worcestershire brine, extracted from Richardson and Watts' *Chemistry as applied to Arts and Manufactures.*

Constituents in 100 Parts Brine.	Cheshire.		Worcestershire.	
	Marston.	Wheelock.	Droitwich.	Stoke.
Chloride of sodium	25·222	25·333	22·452	25·492
Chloride of potassium	..	..	..	..
Bromide of sodium	·011	·020	trace	trace
Iodide of sodium	trace	trace	trace	trace
Chloride of magnesium	..	·171	..	..
Sulphate of potash	trace	trace	trace	trace
Sulphate of soda	·146	..	·390	·594
Sulphate of magnesia	..	..	..	..
Sulphate of lime	·391	·418	·387	·261
Carbonate of soda	·036	..	·115	·016
Carbonate of magnesia	·107	·107	·034	·034
Carbonate of manganese	trace	trace	..	..
Carbonate of lime	trace	trace	trace	trace
Phosphate of lime	trace	trace	trace	trace
Phosphate of ferric oxide	trace	trace	trace	trace
Alumina	trace	trace	..	..
Silica	..	..	trace	trace
	25·913	26·049	23·378	26·397

Another Table of direct results of analyses calculated in 100 parts runs thus:

	Droitwich brine.			Stoke brine.		
	I.	II.	Mean.	I.	II.	Mean.
Potassa	..	..	trace	..	.	trace
Soda	12·1501	12·1217	12·1359	13·7804	13·7754	13·7779
Lime	·1581	·1612	·1596	·1102	·1049	·1075
Magnesia	·0167	·0159	·0163	·0187	·0143	·0165
Sesquioxide of iron	..	..	trace	..	..	trace
Chlorine	13·6167	13·6329	13·6248	15·4479	15·4916	15·4997
Bromine	..	..	trace	..	..	trace
Sulphuric acid	·4886	·4876	·4881	·4896	·4880	·4888
Phosphoric acid	..	..	trace	..	..	trace
Silicic acid	..	..	trace	..	..	trace
Residue on direct evaporation	23·4205	23·4205	23·4205	26·4632	26·4866	26·4749

The following Table in round figures will show the relative strength of some English, compared with some foreign brines:

	Per cent.
Northwich	25
Winsford	25
Droitwich	25
Lüneberg	25
Schönebeck	8 to 11
Fredericshall	20
Rottenmünster	26
Château Salins	14
Arc	3 to 8
Dieuze	14
Onondaga	14 to 18
Goderich	26
Moutiers	2

For further analyses of brines, see Table III. at end of chapter.

British white salt holds its own for general purposes against the productions of all countries; but it is still supposed in some quarters that it is inferior to, or rather not so well adapted for the preservation of fish and other animal food, as the salt procured from France, Spain, Portugal, and other warm climates, where it is prepared by the spontaneous evaporation of sea-water. Hence large sums of money used to be paid every year to foreign nations for the supply of an article which Great Britain possesses, beyond almost any other country in Europe, the means of drawing from her own internal resources. Some years ago Dr. Henry instituted a careful inquiry into the subject, feeling how important it was to ascertain whether this preference for foreign salt was founded on accurate experience, or was merely a matter of prejudice: and whether any chemical difference could be discovered to explain the superiority of the one to the other. The result was, that the slight difference in chemical composition discovered by him was scarcely sufficient to account for those properties imputed to them. The stoved and fishery salt, for example, though differing in a very trivial degree as to the kind or propor-

tions of their ingredients, are adapted to widely different uses. Thus the large-grained salt is peculiarly fitted for the packing of fish and other provisions. Its suitability for preserving food must therefore depend on some mechanical property; and the only obvious one is the size of the crystals and its degree of compactness and hardness. Quickness of solution, it is well known, is nearly proportional, all other circumstances being equal, to the quantity of surface exposed. And since the surfaces of cubes are as the squares of their sides, it should follow that a salt whose crystals are of a given magnitude, will dissolve four times more slowly than one whose cubes are only half the size. That kind of salt, then, which possesses most eminently the combined properties of hardness, compactness, and perfection of crystals, will be best adapted to the purpose of packing provisions, because it will remain permanently between the different layers, or will be very gradually dissolved by the fluids that exude, thus furnishing a slow but constant supply of saturated brine. On the other hand, for preparing the pickle, or for striking the meat, which is done by immersion in a saturated solution of salt, the smaller-grained varieties answer equally well or, on account of their greater solubility, even better.

It is a consolation to know in these days, when by some persons "adulteration" is looked upon as a "form of competition" that our common table salt is not tampered with, though any credit attaching to this fact is to be attributed to the cheapness of the article, which it would not pay to adulterate, rather than to any other cause.

The actual purity of the table salt produced by various manufacturers differs somewhat in degree; and those who produce the best should have the credit of it. At the same time, however, unless it be heresy to say so, the impurities in those productions which are found on chemical analysis to be inferior to others, are so slight, that they could hardly affect the health of those who consume them. English table salt may truly be said to be the best and purest

in the world, and it is a fact that foreigners use it when they can get it in preference to any other.

For analysis of white salt, see Tables IV. and V. at end of chapter.

The analyses of rock-salt show that the transparent portion which is found in small quantities is almost pure chloride of sodium, and has no admixture of earth or earthy salts, or any combination of chloride of lime or magnesia; and that the less transparent portions consisted of chloride of sodium, with a certain proportion of earth or common clay, varying from one to thirty per cent. In each 480 grains it was found, that some of the specimens contained a few grains of sulphate of lime, and that the quantity of pure rock-salt which can be held in solution by a given quantity of water was 6 oz. of salt to 16 oz. of water. The following have been given as the constituent parts of Marston rock-salt:

Chloride of sodium	96·70
Chloride of calcium	·68
Sulphate of lime	·25
Potassium	trace
Magnesium	trace
Water	·63
Insoluble matter	1·74
	100·00

But the constituent parts of rock-salt vary so considerably with the portion of the beds from which it is taken, that it is likely that the percentage of earthy matters found in the different brines will vary with that of the rock-salt from which it is formed. If the same spring were at all times formed from solution of rock-salt of the same purity, some conclusion might be drawn as to the identity of the respective springs; but the constant lowering of the rock-head, by which layer after layer containing different portions of earthy matter are in turn dissolved, preclude much, if any, reliance being placed in this respect; and the same may be said with regard to the strength, which is affected by the quantity of fresh water

finding access to it, either through the sides of the shaft where it is pumped, or through the surface of the earth and by other circumstances. One of these, as Dr. Holland pointed out, is the extent of the surface of the rock-salt exposed to the water. If the brine be pumped up seldom, it is found to be weaker than it would be if it were drawn up more frequently, as the water on the stratum of rock-salt remains almost at rest till put in motion; whilst by raising the brine when in this state, the portion of it which is immediately in contact with the rock-salt becomes saturated. Acquiring, however, at the same time a greater degree of specific gravity than it had as pure water, it prevents the water above from sinking down so as to act upon the rock-salt, and the sum of solution is consequently less than when the pit is frequently worked and the rock-salt exposed to a more constant action of the water.

For further analyses of rock-salt see Table VI. at end of this chapter.

TABLE I.—COMPOSITION OF SEA-WATERS.

LOCALITIES.	English Channel.			Atlantic.		Mediterranean.		North Sea.	Caspian Sea.	Black Sea.	Dead Sea.
AUTHORITIES.	Riegel.	Schweitzer.	Laboulaye.	Ure.	Boullion Lagrange et Vogel.	Laurent.	Ann. de Ch. and Ph., Sept., 1849.	Clemm.	H. Rose.	Gobel.	Fleck.
CONSTITUENTS.											
Sodium chloride	2·4632	2·7060	2·50	2·789	2·510	2·722	2·9424	2·484	0·754	1·4019	7·405
Potassium chloride	0·0307	0·0765	..	0·154	..	0·001	0·0505	0 135	..	0·0189	1·690
Magnesium chloride	0·2564	0·3666	0·35	0·233	0·350	0·614	0·3219	0·242	..	0·1305	12·811
Calcium chloride	0·0439	..	..	..	..	..	..	..	..	..	3·536
Magnesium cromide	0·0147	0·0030	..	..	..	..	..	..	..	0·0005	..
Sodium cromide	..	..	..	0·052	..	..	0·0556	..	..	..	0·502
Calcium sulphate	0·1097	0·1406	0·01	0·155	0·015	0·045	0·1357	0·120	..	0·0105	0·121
Magnesium sulphate	0·2146	0·2300	0·58	0·184	0·578	0·702	0·2477	0·206	0·406	0·1470	..
Sodium sulphate	..	..	..	..	..	..	..	..	0·036	..	1·217
Calcium carbonate	0·0176	0·0030	0·02	..	}0·020	0·020	{0·0114	..	0·018	0·0365	..
Magnesium carbonate	0·0078	..	..	..			..	..	0·440	0·0289	..
Ferric chloride	..	..	..	..	..	..	0·0003	..	..	..	..
Water	96·8414	96·4743	96·54	96·433	96·527	95·896	96·2904	96·813	98·346	98·2253	73·926
Total	100·0000	100·0000	100·00	100·000	100·000	100·000	100·0000	100·000	100·000	100·0000	100·000
Percentage of solid constituents	3·1586	3·5257	3·46	3·567	3·473	4·104	3·7655	3·187	1·654	1·7747	26·065

The percentage of solid constituents, and especially of sodium chloride (salt) in the Dead Sea as given in the above table, is to be specially noticed.

TABLE II.—ANALYSES OF SEA SALTS FROM WELL-KNOWN LOCALITIES.

LOCALITY.	St. Ubes.						St. Martin.	From Brittany, Marais, Salants de l'Ouest.	Island of Oleron.	Sallns du Midi.	Cadiz.	St. Felice Trappani.	
AUTHORITY.	Henry.	Berthier.		Karsten.			Henry.	Enquête sur les Sels.	Henry.	Enquête sur les Sels.	Watts.	Schrotter and Pohl.	
CONSTITUENTS.													
Sodium chloride	96·00	95·19	89·19	95·86	92·46	96·50	95·95	87·97	96·40	95·11	92·11	95·91	96·50
Magnesium chloride	0·30	..	..	0·24	0·55	0·32	0·35	1·58	0·20	0·23	..	0·46	0·50
Magnesium sulphate	0·45	1·69	6·20	0·35	0·66	0·25	0·60	0·50	0·45	1·30	0·99	0·40	0·51
Sodium sulphate	..	..	..	..	..	..	..	..	..	..	..	..	..
Calcium sulphate	2·35	0·56	0·81	[illegible]	[illegible]	0·88	1·90	1·65	1·95	0·91	0·33	0·49	0·45
Water	..	..	0·20	2·10	3·10	1·95	..	7·50	..	2·35	6·30	2·53	2·42
Insoluble matters	0·90	2·45	3·60	0·15	0·95	0·10	1·20	0·80	1·00	0·10	0·27	0·16	0·07
Loss	..	0·11	..	..	..	..	..	..	..	..	..	..	..
Total	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

TABLE III.—ANALYSES OF BRINES.

AUTHORITY.	A. B. Northcote.				Heine.		Fehling.				Maxwell Lyte.
LOCALITY.	Cheshire. Marston.	Cheshire. Wenlock.	Worcestershire. Droitwich.	Worcestershire. Stoke Prior.	Schönebeck. Before Gradation.	Schönebeck. After Gradation.	Clemenhall.	Sulz.	Friedrichshall. Wurtemburg.	New York Salina from the Carboniferous Formations.	Dax in the South of France.
CONSTITUENTS.											
Sodium chloride	25·222	25·333	22·452	25·492	10·404	25·160	25·902	23·473	25·563	13·239	25·273
Magnesium	..	0·171	..	..	0·073	0·630	Traces	..	0·006	0·046	0·030
Calcium	..	..	..	..	..	..	..	..	..	0·083	0·105
Sodium cromide	0·011	0·020	Traces	Traces	..	..	..	..	..	..	0·016
Sodium iodide	..	..	..	..	..	..	..	..	..	..	..
Sodium sulphate	0·146	..	0·390	0·594	..	..	0·019	..	..	..	..
Potassium	Traces	Traces	Traces	Traces	0·148	0·550	..	..	..	..	..
Magnesium	..	..	..	..	..	0·130	0·610	..	0·002	..	..
Calcium	0·391	0·418	0·387	0·261	0·284	0·170	0·444	0·508	0·437	0·569	0·357
Sodium carbonate	0·036	..	0·115	0·016	..	..	..	..	..	..	..
Calcium	..	0·052	..	..	0·049	..	0·019	0·016	0·010	0·014	0·015
Ferric oxide and alumina	..	..	..	..	..	..	..	..	..	0·002	0·012
Silica	..	..	..	..	..	..	..	..	..	..	0·005
Water	..	..	..	..	..	..	73·615	..	73·982	..	..

In this Table the presence of calcium chloride in the Dax brine, of the sodium sulphate in the Worcestershire brine, and the large proportion of potassium sulphate in the Schonebeck brine are specially to be noticed. It is stated by the salt makers of Cheshire that the Worcestershire brine works far more easily than theirs. If such be the case, it may be attributable to this peculiarity of composition.

TABLE IV.—ANALYSES OF COMMERCIAL WHITE SALTS.

AUTHORITIES.	Henry.	Ure.	Watts.		Richardson and Watts.	Fehling.		Maxwell Lyte.	Crace Calvert.	Maxwell Lyte.	Virch.		Heine.
LOCALITY.	Cheshire, Fishery dried at 212° F.	Cheshire Stoved.	Schönebeck.	Stassfurt.	Spencer New York.	Wilhelms-Glück.	Friedrichshall, Butter Salt.	Dax, Common Salt. France.	Cheshire Agricultural Salt.	Machine Pan Butter Salt from Winsford.	Salz in Mecklenburg Butter Salt.	Salz in Mecklenburg Common Salt.	Artern.
CONSTITUENTS.													
Sodium chloride	98·60	98·250	95·402	97·094	96·29	98·900	97·550	98·500	95·82	95·272	93·79	90·75	96·53
Potassium	..	..	..	..	Trace	..	..	..	..	..	0·89	1·00	..
Calcium	..	0·025	..	0·345	Trace	..	..	0·010	Trace	..	0·26	0·99	..
Magnesium	1·10	0·075	0·800	..	0·27	..	..	0·037	..	0·014	0·14	0·60	..
Sodium sulphate	..	..	..	..	Trace	0·005	..	..	..	..	..	..	0·96
Potassium	..	..	0·414	..	..	..	..	..	..	..	..	..	..
Calcium	1·20	1·550	0·732	0·390	1·39	0·498	0·934	0·452	..	1·900	1·44	0·59	0·64
Magnesium	..	..	0·471	0·727	..	..	0·009	..	..	..	..	..	..
Ferric oxide and alumina	..	..	..	0·180	0·25	..	..	0·090	..	0·160	..	..	..
Insoluble matter	0·10	..	..	..	0·03	..	..	..	..	0·041	..	..	..
Calcium carbonate	..	..	..	..	..	0·005	0·016	..	..	..	..	..	..
Water	..	..	2·901	1·264	2·20	0·602	1·488	1·890	4·18	2·605	3·88	6·48	1·86
Total	101·00	99·890	99·920	100·001	99·23	100·010	99·[illegible]7	99·889	100·00	99·992	..	..	..

TABLE V.—ANALYSES OF AMERICAN AND ENGLISH SALTS (Porter and Goessman.)

LOCALITY.	AMERICAN.									ENGLISH.			
	Fine Boiled Salts.			Coarse Salts.		Dairy Salt.		Ashton.		Stubbs.	Ashton. Northwich.	Deakin.	Marshall.
	Onondaga.	Hocking Valley.	Mason City.	Onondaga.	Turk's Island.	Onondaga.							
CONSTITUENTS.													
Sodium chloride.	97·12	93·26	95·77	97·31	96·76	97·760	97·672	97·59	97·660	98·0229	97·7598	97·4728	98·4065
Calcium . . .	0·15	1·43	0·61	0·05	..	..	..	0·01	..	..	..	..	..
Magnesium . .	0·13	0·70	0·04	0·05	0·14	..	..	0·03	0·059	0·0124	0·0591	0·0353	..
Sodium sulphate	..	..	..	..	0.64	0·025	0·008	..	..	..	..	..	0·1135
Calcium . . .	1·33	..	..	1·05	1·56	1·295	1·235	1·67	1·381	1·3798	1·2272	1·4413	0·8883
Magnesium . .	..	..	..	..	..	0·066	0·082	..	..	0·0817	0·0769	..	0·0281
Insoluble matter.	..	0·01	0·11	..	..	0·130	0·124	..	..	0·0616	0·0564	0·0490	0·0500
Water . . .	1·27	4·60	3·47	1·54	0·90	0·724	0.879	0·70	0·900	0·5620	0·7880	0·9520	0·4940
Total . .	100·00	100·00	100·00	100·00	100·00	100·000	100·000	100·00	100·000	100·1204	99·9674	100·0757	99·9809

Is to be noted that samples taken fresh from the bins generally contain more water than shown in the analyses, unless the salt has been dried before storage. The water usually amounts to 3-4 per cent. for butter-salt, 5-6 for common salt, and 7-8 for fishery-salts, while some extra fishery-salts contain even more. This water, however, being for the most part merely mechanically held between the crystals, drains away during transit or long storage.

2 2 2

TABLE VI.—COMPOSITION OF ROCK-SALTS FROM WELL-KNOWN LOCALITIES.

COUNTRY.	GERMANY.								FRANCE.	AUSTRIA.		ENGLAND.	
LOCALITY.	Schwabisch Hall, Wurtemburg.		Merchtesgaden, Bavaria.	Stassfurt near Magdeburg.	Château Salins, Lorraine.	Vic in German Lorraine.			Dax.	Hall.	Wieliczka, Galicia.	Rock-salt from Cheshire.	Rock-salt from the Marston mine, Northwich
AUTHORITY.	Fehling.		Bischof.	Rammelsburg.	Mathieu de Dombasle.	Berthier.		Cordier.	Maxwell Lyte.	Bischof.	Bischof.	Richardson and Watts.	Crace Calvert.
CONSTITUENTS.													
Sodium chloride . .	99·97	98·81	99·85	94·57	97·05	99·30	97·80	97·45	96·97	99·43	100·00	98·30	96·70
Calcium chloride .	..	0·02	trace	..	..	..	..	..	..	0·25	..	..	0·68
Magnesium chloride	..	trace	0·15	0·97	0·45	..	..	..	0·51	0·12	..	0·05	trace
Potassium chloride .	..	..	..	..	..	..	..	..	trace	..	..	..	trace
Calcium sulphate .	0·02	0·11	..	0·89	1·50	0·50	0·30	0·25	0·23	0·20	..	1·65	0·25
Magnesium sulphate	..	..	..	..	trace	..	..	2·30	..	..	..	..	..
Magnesium carbonate	..	0·15	..	..	..	..	..	..	..	..	..	..	..
Calcium carbonate .	..	0·16	..	..	..	..	..	..	..	..	..	..	..
Ferric chloride . .	..	..	..	..	..	..	..	..	0·01	..	..	..	..
Clay or insoluble matters . . .	0·01	0·80	..	3·35	..	0·20	1·90	..	2·28	..	..	..	1·74
Water or loss . .	..	..	..	0·22	1·00	..	..	..	..	..	..	..	0·63
Total . .	100·00	100·05	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

CHAPTER VI.

THE SALT TRADE:—STATISTICS OF PRODUCTION IN GREAT BRITAIN — EXPORTS — MANUFACTURERS — PANS—COST OF PRODUCTION—PRICES—PROFITS—PROSPECTS OF TRADE—HEALTH AND WAGES OF OPERATIVES.

THE interests of the Salt Trade in this country are carefully watched over by the Salt Chamber of Commerce, which was formally installed at a numerous meeting of proprietors held at Northwich, on the 30th of August, 1858, its fundamental principles being the formation of an efficient representative body for the extension, general advancement, and protection of the trade. The Chamber, of which all the chief salt proprietors in the kingdom are members, has energetically pursued the objects of its institution, and successfully extended the consumption of salt in markets already established, and brought about the opening of fresh ones. Its yearly reports are replete with useful and interesting information in reference to the progress and requirements of the trade.

It is difficult, now that we get salt at an almost nominal price, to realize the fact that it was once heavily taxed in this country. It seems that salt duties were first exacted in 1702, and renewed in 1732. In 1783 and 1785, Acts of Parliament were passed prohibiting the use of refuse salt by farmers, and from that time until 1819 the law compelled salt manufacturers to throw it into the river in the presence of examiners of the customs, lest it should be used by farmers to defraud the revenue. In 1798 the duty was 5*s.* per bushel, which was subsequently raised to 15*s.*, thus making its cost thirty times greater than that of its manufacture. During the French war, the duty amounted to

over 30*l.* per ton, and, when at its highest, produced a revenue of about 1,500,000*l.* a year; and it is not to be wondered at that such fiscal arrangements led to salt smuggling and a variety of devices for evading the duty. It was reduced in 1823, and finally ceased altogether in 1825, since which date the trade has been entirely free and unrestricted. Between 1823 and 1825 the retail price of salt was between 4*d.* and 5*d.* per lb.: it is now one halfpenny. It has been computed that the people of this country require and consume about 16 lbs. of salt per head annually. There are some who still think that an imposition of a duty of from half-a-crown to five shillings per ton, or even more, might be imposed without any adverse effect on the trade, and without its being felt by the consumer. But though a revenue of from a quarter to half a million might thus easily be obtained, such a proceeding would be so contrary to the spirit of modern commercial legislation that it is not likely to be seriously proposed, except under most extraordinary circumstances. Few taxes are really more cruel than those on salt; and yet many Governments have from time to time made them to be among the chief sources of revenue.

As with analysis, so with statistics—the latter, like the former, must of necessity be introduced however uninteresting they may be to many readers; and this chapter will have its full share of them.

The periods of great development in the salt trade appear to have been simultaneous with certain causes, such as the repeal of the duty, the increased use of salt in agriculture, smelting, and manufacturing, and especially when it became substituted for seaweed or kelp in the manufacture of soda, and led to the concurrent large increase in that trade. In 1671, when the Weaver was first made navigable to Winsford, only two salt-works were in operation at that place, and those on a very small scale. About the year 1825, probably just after the repeal of the duty, it appears that the whole manufacture of Northwich and Winsford did not exceed 250,000 tons annually.

During the next twenty years the production greatly increased; and in the year 1844 we find that the total salt production of the country including both rock and white salt was about 1,306,224 tons. Passing on to 1875, the returns for that year show that the manufacture of white salt from brine alone in Cheshire and Worcestershire amounted to 1,779,000 tons; and in 1876 to 1,673,540; illustrating, as subsequent years have done, that various causes, and especially the export trade, influence the output. Coming nearer to the present date, we have the following return of the production of white salt from brine alone in 1881:—

		Tons.
Cheshire—	Northwich	500,000
	Winsford	1,000,000
	Middlewich	30,000
	Wheelock and Lawton	100,000
Staffordshire—	Shirleywick and Weston-on-Trent	4,000
Worcestershire—	Droitwich	115,000
	Stoke Prior	105,000
	Total	1,854,000

Averaging the brine to contain 25 per cent. of salt, these 1,800,000 tons of white salt manufactured in 1881 represent 7,200,000 tons of brine, which with the loss and waste averaged at 25 per cent. is equal to 9,000,000 tons of brine used annually.

A small quantity of white salt is manufactured at Duncrue in Ireland from the rock salt dissolved by water into brine; and at some other places rock-salt is used for strengthening weak brine.

The production of rock-salt, according to the returns under the Metalliferous Mines Regulation Act, under which rock-salt mines are classed is thus stated for ten years to 1881 inclusive:—

		Tons.		Tons.		Tons.
1872. . .	In Cheshire,	137,916	In Ireland,	32,941	Total,	170,857
1873. . .	"	143,597	"	33,751	"	177,348
1874. . .	"	172,855	"	27,951	"	200,806
1875. . .	"	158,044	"	33,075	"	191,119

		Tons.		Tons.		Tons.
1876. . .	In Cheshire,	154,531	In Ireland,	32,310	Total,	186,841
1877. . .	"	179,417	"	28,525	"	207,942
1878. . .	"	152,829	"	30,101	"	182,930
1879. . .	"	159,575	"	30,234	"	189,809
1880. . .	"	167,446	"	31,298	"	198,744
1881. . .	"	166,740	"	30,891	"	197,631

The figures just given, representing the total out-put of rock-salt in England and Ireland for the year 1881, added to those representing the production of white salt in England for the same year, give us of both kinds of salt a total production of over *Two Million Tons*, the exact figures being 2,051,631. Of this the larger moiety, as will be seen a little further on, was exported, the rest being used in this country as a condiment and for a variety of other purposes.

Various statistics of exports of salt from the United Kingdom show the steady growth of the trade. Looking back only as far as 1844 we find that the export of salt amounted to no more than 673,844 tons. The distribution of this quantity as given in *bushels* (13,476,884), show who were our best customers at that date:—

	Bushels.
Russia	1,823,756
Denmark	462,576
Prussia	1,686,520
Holland	799,802
Belgium	1,041,028
Sweden and Norway	237,594
Germany	301,426
British North American Colonies. .	1,772,799
United States of America . . .	4,664,430
Western Coast of Africa . . .	374,452
New South Wales	125,801
Guernsey, Jersey, &c.. . . .	41,032

The remaining quantity was sent in small shipments to the West Indies, ports in the Mediterranean, River Plate, &c. Taking almost at haphazard three subsequent quinquennial periods, as given in the official Parliamentary Blue Book, we find that in the five years from 1847 to 1851, the exports reached 2,195,605; from 1857 to 1861 the total

was 3,201,409 tons; and from 1867 to 1871 the amount was 4,011,659 tons.

The ports from which Cheshire salt is shipped are, Liverpool, Runcorn, and Weston; and to some slight extent Hull, and Grimsby. To Hull and Grimsby the salt is sent by rail; to Liverpool, Runcorn, and Weston Point, by water, either down the River Weaver, which by an Act of Parliament passed in 1721 was made navigable, and is continued navigable from Winsford Bridge to the Mersey; or down the Trent and Mersey, and Bridgwater Canals. The shipping ports for Worcestershire salt are Gloucester and Bristol; but the chief manufacture at Droitwich and Stoke Prior is for the inland trade and home consumption.

Let us now take two or three separate years of more recent date, with the "Statements of White and Rock-Salt shipped from Liverpool, Runcorn, and Weston," the three shipping ports on the Mersey, as published by the "Salt Chamber of Commerce." These will still further show us the increase in the export trade, and also its fluctuations: and by comparing them with the table just above given referring to the year 1844 and with one another we shall be able to see which countries have been our best customers of recent years, and which are so at the present time:—

From LIVERPOOL :—	One year to 31st Dec., 1871.
	Tons.
To United States	182,939
„ British North America	94,382
„ West Indies and South America	9,130
„ Africa	22,685
„ East Indies	271,119
„ Australia	9,192
„ Baltic and North of Europe	98,683
„ France and Mediterranean	1,898
„ Coastwise	91,720
„ Holland and Belgium	60,544
Total from Liverpool	842,292
From Runcorn	169,736
„ Weston Dock	43,699
Grand Total	1,055,727

The preceding statement is for 1871. This was the first year in which the exports exceeded 1,000,000 tons; and at no former period had so much salt been manufactured and sold in one year in this country.

In each of the next three years (1872–3–4) the exports from the Mersey fell a little below a million tons, but in 1875 they again reached that amount, and the statement for that year is as follows :—

From LIVERPOOL :—	One year to 31st Dec., 1875.
	Tons.
To United States	212,532
„ British North America	54,807
„ West Indies and South America	4,442
„ Africa	25,507
„ East Indies	311,107
„ Australia	24,918
„ Baltic and North Europe	101,989
„ France and Mediterranean	889
„ Coastwise	72,268
„ Holland and Belgium	62,917
Total from Liverpool	871,376
From Runcorn	71,018
„ Weston Dock	90,093
Grand Total	1,032,487

The exports then again fell below a million tons till we get to the year 1879, when the figures stood at 1,086,850 tons. In 1880 they rose to 1,201,496 tons. For the three last years up to 31st December last, the table stands as given on page 17.

From these tables it will be seen that the United States and India have for many years been the best customers of our salt trade, and France our worst, the import of English salt into the last-mentioned country being still practically prohibitory, though there have been many negotiations between the Governments of the two countries in reference to a modification of fiscal arrangements as regards this commodity.

A whole volume might be written on the subject of salt

From LIVERPOOL :—	One year to 31st Dec., 1881.	One year to 31st Dec., 1882.	One year to 31st Dec., 1883.
	Tons.	Tons.	Tons.
To United States	228,891	223,602	239,459
,, British North America	80,784	81,716	99,352
,, West Indies and South America	15,556	23,935	25,413
,, Africa	25,181	34,287	36,896
,, East Indies	324,109	274,866	316,327
,, Australia	23,872	17,232	10,860
,, Baltic and North Europe	100,957	116,509	107,978
,, France and Mediterranean	1,187	5,001	2,803
,, Coastwise	41,653	32,462	46,753
,, Holland and Belgium	67,780	67,334	72,353
Total from Liverpool	909,970	876,962	958,194
From Runcorn	148,122	146,716	141,021
,, Weston Dock	85,545	68,147	87,954
Grand total	1,143,637	1,091,825	1,187,169

in India, and yet not exhaust the subject. Till within the last twenty years, salt making and selling was entirely a Government monopoly over the whole dependency, but the salt produced, whether from washing salt soil, from the mines in the salt range in the Punjaub, or from evaporation of sea-water on the coast, was, and is still, of an inferior character, more or less dirty in colour, and containing from 10 to 12 per cent. of impurities. Various changes in the fiscal regulations have been made from time to time, but the monopoly has always been productive of great jobbery and a variety of abuses, in consequence of the salt passing through so many hands. Six million pounds sterling annually was a large revenue for the Government to secure from salt, but this was obtained at the expense of the natives, who in some districts spent as much as one-sixth of their annual earnings upon what is absolutely a necessary of life to a people whose food is peculiarly insipid, and who use little fish or animal diet. As long ago as 1831–32 a Parliamentary Committee stated that the price of salt in some districts of India was about 288 per cent. above the original cost and charges. It also expressed an opinion that the Bengal Presidency might obtain a cheaper supply by importation from the coast of Coromandel, Ceylon, and

elsewhere, and even from Great Britain, than by the existing system of home manufacture, and recommended that the Government should contract for the delivery of salt, by advertisement, into the public warehouses of the port of Calcutta, at a certain price per ton, and that in the interest of the natives the home manufacture should be gradually diminished. It was not, however, till 1863, through the instrumentality of Sir Charles Wood, that the Government monopoly was abolished in the Bengal Presidency, and salt admitted *into bond* at Calcutta, with a customs duty of about £6 per ton, payable on its being taken out.

Several alterations in the duties have been made since the above date. They were raised about the time of the Mutiny in 1857. In 1878 they were lowered; and again in March 1883 they were lowered throughout British India, and arrangements made with the Native States, under British protection, for the purchase and control of their salt works; and the duties were equalised in the different provinces. This all-important equalisation of the duties on salt in India, after years of patient negotiation, must eventually prove a great boon to the trade, by increasing the consumption of English salt in that country. As yet there has been hardly time to test the full benefit of this great measure; but that it will lead to a generally increased consumption of English salt, particularly of manufactured English salt, is unquestionable, as soon as the latter finds its way into distant provinces. It is almost impossible to over-estimate the benefit conferred upon the natives by the reduction of the price of salt, and recent fiscal regulations, it being calculated that the consumption is reckoned at about 13 lbs. per head of a population over 200 millions. The average price they now pay for their salt may be put in a very rough way at about 1*d.* per lb., which is only double the price of the commodity in this country. At the same time it is satisfactory to know that the public revenue has not suffered, and, after land, salt still yields the largest contribution to the Indian Exchequer, the

figures it represented in 1882 being close upon seven millions sterling. While this Handbook was passing through the press, the Under-Secretary of State for India was asked whether, considering the alarm throughout Europe at the spread of Asiatic cholera, and in view of the fact that there was so often a deficiency of salt found in the blood of persons dying from this disease, and that vast numbers of the natives of India were not able to procure a sufficiency of salt, Her Majesty's Government would at once abolish the salt tax in India. The answer given by Mr. J. K. Cross was to the effect that it was not a fact that a vast number of the people were unable to obtain a sufficient quantity of salt. He was not aware that this question had any relation to cholera in India. A further question was then put, whether it was the case that since 1882 the Excise regulations respecting the salt monopoly had been made more strict in the Madras Presidency; and whether the Government intended to give the native population the inestimable boon of further reductions in the salt rates. The answer was in the negative.

Readers who are specially interested in this question of the Indian salt supply, and our salt trade with that part of our Empire, cannot do better than obtain a pamphlet entitled "Salt in India," published at Northwich in 1880, and presented to the Salt Chamber of Commerce. It is written by Mr. H. E. Falk, one of the largest salt manufacturers in Cheshire, and the leading authority on all matters connected with the salt trade. It is mainly through his exertions that the equalisation of the salt duties in India has been brought about. The annual reports also of the Salt Chamber of Commerce for some years past have contained much interesting and valuable information on this subject.

North America is a good customer to our salt manufacturers, partly because its home salt supply is derived from its comparatively weak brine springs, and partly because of the cost of fuel for manufacturing salt from them. In fact, we can make salt of better quality and

more cheaply than at present is possible on the other side of the Atlantic. After a long contention between the advocates of free trade and the upholders of the salt monopoly in the United States, the former succeeded, in 1872, in getting the import duties on salt reduced to 8 cents for "bulk" and 12 cents per 100 lb. for "sack" salt, and the effect of this reduction was soon seen. American shipments are almost entirely made at Liverpool, as American vessels which bring over cotton thus get freights back. The reduction of the duties therefore by the States has not only been to the advantage of the Cheshire manufacturers, but it has materially benefited both English and American shipping. A further reduction of the duties would still further benefit both our manufacturers and their customers. On this subject Mr. H. E. Falk, in a pamphlet he wrote on "Salt in North America" in 1877, after a visit to that country in the previous year, says:—"I am happy to have to report so little cause for alarm on our part. America is growing with giant strides, and the consumption of salt for manifold purposes is increasing amazingly. But, like all civilized communities, it becomes more and more fastidious about the quality of all the articles it consumes, and more especially the edible portion of them. Therefore, if Cheshire salt is to hold its place in the American market, it must be sent out and arrive there clear and clean as it comes from the pans that produce it. I am clearly of opinion that the whole of the American salt works are simply fit to supply local demands, were they to be left, which they undoubtedly will be some day, without the high protective duty. The great consumers of the West will not submit, in a free country like America, to be taxed heavily for the purpose of propping up an artificial industry, which labours under the greatest disadvantages in the principal supply of the article it has to manipulate. The whole of the salt districts I have visited would not be looked at in England for a supply of brine. The weakness and impurity of this first essential for salt manufacture make it unfit for free-trade manufacture. The only

profitably worked salt districts in England are those belonging to the new or Tertiary geological period, as they supply the pure brines. Those of the American district all belong to an older period, and consequently, besides being costly to get at, are impure and weak. The splendid system of American railways will contribute more than any other circumstance to an early revision of the tariff, as free trade is as the life's blood to these great arteries of internal communication."

The increase in the salt trade may also be partly gathered from the comparison of the number of "pans" at work in different years, which the following table will show :—

District.	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883
Winsford .	459	489	503	517	523	541	554	567	595	616	624	612	607	629	638	631	631
Northwich .	293	316	343	351	355	388	393	400	434	462	478	484	485	453	459	461	465
Middlewich .	..	..	..	13	13	13	13	11	11	12	12	13	13	13	13	13	13
Sandbach .	..	..	..	60	60	61	62	67	67	67	67	68	68	69	69	68	68
Droitwich Dis.	..	..	..	137	141	145	148	153	154	154	151	151	151	151	151	144	135

As on an average a salt-pan will make about 1000 tons per annum, the business of a firm can be judged by the number of pans which they have at work.

There are over fifty salt works in the Cheshire district owned either by private firms or public companies. In the Worcestershire district the two great firms are those of Mr. John Corbett, M.P., at Stoke Prior, and of the Droitwich Salt Co. at Droitwich. Beds of rock-salt underlie this district, and the brine-springs from which the salt is made are simply springs of water saturated, or very nearly so, with salt from the rock. At Droitwich, which is the original seat of the salt manufacture, these springs used to rise to the surface, the name of the settlement in Roman times, "*Salinæ*," pointing to this fact. The subterranean resources, however, having been drawn upon through a long series of years, the brine has become more

difficult to obtain, and at present is reached by shafts (lined with iron cylinders to prevent the entry of fresh water) from 80 feet to 100 feet deep, in which it rises to within about 30 feet of the surface. The salt works of Mr. Corbett are among the largest in England, and are certainly the most complete of their kind, covering an area of more than 22 acres. Here the brine is pumped from wells varying from 300 feet to 800 feet deep, an increase of depth, as compared with Droitwich, which is rather to be attributed to the conformation of the surface of the ground than to any difference in the position of the salt-bearing strata. The full weekly production at the two establishments would be over 6000 tons, if always at full work; and the three kinds of salt chiefly made are "butter," "table," and "broad" salt, the latter being largely used for agricultural purposes. Mr. Corbett is the patentee of a new mode of preparing salt of a superior fineness and hardness, which consists in the use of a covered pan, inside of which a number of rakes are made to revolve by steam-power. The agitation of the brine and the greater heat caused by the retention of the steam combine to produce a more rapid deposition of the salt, the crystals of which are consequently very fine and hard. Mr. Corbett has also provided model cottages at a moderate rent for his workpeople, and supplied them with schools, a dispensary, and buildings for religious services, and thus made his works at Stoke Prior quite a model manufacturing establishment.

Maldon, in Essex, has been the seat of a salt manufactory for a great number of years; and there the Maldon Crystal Salt Company turn out many tons per week of a salt from sea-water. It is prepared with the greatest care, and is of absolute purity. It is produced and sold in large crystals, which some persons prefer to small-grained salt; and in this form is highly esteemed by many connoisseurs, who also appreciate its pretty appearance on the table in tasteful salt-cellars. Crystal salt is sometimes seen of a pink colour, which is probably given to it by cochineal; but this is not a production of the Maldon Company. The colouring seems

to be added simply to increase its attractiveness on the table.

The price of salt depends mainly on the cost of fuel, and partly on that of iron, which is used for the pans and for other parts of the "plant," and soon perishes from the action of the salt, while at the same time, as in the case of other articles, the price fluctuates according to supply and demand. "Common" salt, which is the cheapest made, forms the standard of price, all the other qualities being regulated by it. For many years, as coal remained pretty steady, salt fluctuated but little. From 1845 to 1850, the average price of common salt was 7*s.* 6*d.* per ton at the works. It fell as low as 5*s.* 3*d.*, and then advanced to 12*s.*, but for short periods. From 1850 to 1860, the price was much the same as in the previous five years. When the American war commenced, prices fell, and during the war averaged about 4*s.* 3*d.* at the works. Some lots were sold as low as 3*s.* 9*d.*, the lowest price ever known. In 1865 the price advanced, and since that period it has been from 6*s.* upwards. In 1872 it reached 20*s.* In 1873 it commenced at 12*s.*, but soon rose to 15*s.* In 1874 it fell from 12*s.* to 8*s.*; in 1875 it kept nearly steady at about 9*s.*; in 1876 the price fluctuated from 8*s.* down to 5*s.*; in 1877 it even fell to 4*s.*, rising again to 7*s.*; in 1878 it was at 7*s.*, and fell to 5*s.* 6*d.*; in 1879 it again went as low as 4*s.* 6*d.*, running on into 1880 through 4*s.* 6*d.*, 4*s.* 9*d.*, to 6*s.* 6*d.*, and back to 6*s.* In 1881 the works' price was rated at Liverpool at 5*s.* 6*d.* for common salt. Last year it may be put at 4*s.* to 4*s.* 6*d.*

According to evidence given before a recent Parliamentary Commission, the cost price of manufacturing common salt in the Winsford and Northwich district is about as follows:—Brine, 6*d.* a ton; labour, 10*d.*–1*s.*; coal (slack), 3*s.*; rent, interest on capital, &c., 1*s.*; total, 5*s.* 4*d.*–5*s.* 6*d.* a ton; but these are subject to many important variations. To the above costs are to be added those of carriage to various ports of shipment.

In addition to its use as a condiment and an antiseptic, the demand for salt for a variety of other purposes affects

its price and the profit of the manufacturer. Salt is extensively used in agriculture, an ancient practice in vogue in Palestine and China more than 2000 years ago; and it is possible that there will be a still greater demand for it to mix with ensilage as the use of silos becomes more general. Salt is also largely employed in the manufacture of the various salts of soda, especially the carbonate. The soda used in soap-making and for other purposes was formerly obtained by burning marine plants, such as *Salsola Soda* and *Salicornia herbacea*, on the coasts of the Mediterranean and other warm climates, the ash obtained being called *barilla;* while on some parts of the coasts of Ireland and Scotland an inferior article named "kelp" was produced by burning the *Fucus vesiculosus* and other species of Fuci. The repeal of the duty on salt almost entirely superseded the manufacture of "kelp," the supply of soda being now furnished by the decomposition of common salt by a process invented by a French chemist, Leblanc, at the close of the last century. Salt may be said to have made the alkali trade of this country. Salt is also employed in the preparation of hydrochloric acid; in the glazing of stoneware; in the manufacture of soap, which it hardens; and in that of glass, to which it gives whiteness and clearness. It is largely used in metal-refining works, as it preserves the surfaces of melted metal from calcination by defending them from the air. It is employed with advantage in some assays, also as a mordant, and for improving certain colours; and in dyeing, bleaching, and calico-printing works. In fact it enters more or less into a very large number of art processes and manufactures in this country; and consequently on the condition of trade in a variety of branches the prosperity of the salt industry greatly depends.

On the whole, however, the salt trade, important though it be, is one which does not hold out any very strong inducements for capitalists to enter. It is somewhat precarious in its nature, and easily affected by external circumstances. It is mostly in private hands, by which it

seems better managed than by companies, few of which have paid dividends of an attractive character. Here and there, fortunes have been made; but fortunes have also been lost, in experiments and failures in "pricking," i.e. finding brine. It must be remembered, too, that in several localities of the salt districts symptoms have long been shown of a failure in the brine supply. Many shrewd capitalists, however, outside the trade, think that more might be made of it. In 1872, for instance, several leading capitalists of Manchester invited the salt trade to a conference, having for its object the absorption of the whole salt trade into a Limited Company, which should buy up all existing salt-works, and secure, as far as possible, all salt lands in the neighbourhood of the River Weaver and the railways. The whole question was discussed between the parties interested at Northwich, but no tangible result was arrived at, and the matter seems to have dropped. The movement, however, did some good, by showing salt proprietors the real value of their investments, and also that, if they continue united for their common good and refuse to be the sport of jobbers and shippers, who have so long exercised an undue influence over the trade, they can secure for themselves that legitimate return for their capital to which they are fairly entitled.

As regards the health of the operatives engaged in the salt manufacture, though many of them work in a very high degree of temperature during the greater part of the day, it is on the whole very good. An atmosphere impregnated with salt is, as a matter of fact, a preservative against colds, rheumatism, neuralgia, and other ailments caused by exposure to cold and damp, which are so common among working men. Salt "boilers" or "makers," as they are called, generally live to a good old age, but unfortunately the very nature of their work is provocative of thirst, and leads to some intemperance among them. In Cheshire, as in Worcestershire, they are paid at the rate of so much per ton; and when at full work a man can earn from 30*s.* to 35*s.* per week for making fine salt, i.e.

after paying his "assistants," who help him in "drawing, drying, and warehousing it. For "firing" the pans, h receives something extra. A salt maker employing a average family to assist him, can make about 35 tons c fine salt in a week. The employers deal only with the sal maker, who is thus a contractor on a small scale. Wome are not generally employed in Cheshire; and at the Stok Prior Works, in Worcestershire, Mr. Corbett some time ag succeeded, though after a great deal of trouble, in abolish ing female labour altogether. Wages in Worcestershire, i is said, compare favourably with those in Cheshire, as i the former employment is constant, while in the latter th workmen sometimes lose a good deal of time. It shoul be remembered, as bearing on the question of wages, tha salt-making is little more than drawing salt from the pan and is therefore to a very great extent only unskille labour.

CHAPTER VII.

LANDSLIPS AND SUBSIDENCES OF THE SOIL IN THE SALT DISTRICTS OF CHESHIRE AND WORCESTERSHIRE.

An interesting though somewhat painful circumstance connected with the salt districts of Cheshire is the constant recurrence of landslips and the gradual subsidence of land in many parts. The continual flow of the fresh water over the strata of rock-salt, thereby gradually diminishing the deposits, and the pumping it up in the form of brine, has for ages been gradually thinning the crust of the earth above, and so creating large hollows beneath the surface. This, and the falling in from time to time of the roofs of rock-salt mines, has caused landslips and subsidences of earth, of a more or less serious nature, at different periods in the salt districts, particularly in Cheshire. These displacements having of late years presented more alarming aspects, the Government thought well to instruct Mr. Joseph Dickinson, one of the Inspectors of Mines, to investigate the whole matter. His first Report was published in 1873, and a most interesting one it is, and well worth perusal even by those who are not personally connected with salt manufacture. Mr. Dickinson is not a mere prosaic inspector, but an antiquarian; and informs us that landslips and subsidences began some centuries ago. The first landslip in the salt districts which seems to be recorded in history took place in the year 1533, near Combermere Abbey, concerning which it is said in *Leyland's Itinerary* that "part of a hill, with trees upon it, suddenly sank down and was covered with salt water, of which the abbot being informed, caused it to be wrought; but the proprietors of the Wiches compounding with him, he left off working."

The second landslip was on the 8th of July, 1659, and is recorded in Ormerod's *History of Cheshire*, as happening at a place now called Barnelfall, near Bickley.

All round Northwich these landslips and subsidences, some dating back to remote times, may be witnessed, the ground in some places being torn up into furrows, and still visibly on the move, in one place a depression of about 70 feet having occurred within the memory of man. In the valley between what was once Witton Mill and the River Weaver, where there was a canal, and Witton Brook, a large mere or lake is now being formed, the progress of which can be traced from time to time by referring to maps of the district made at different periods. In this part the water has made its way into different mines, and a great portion of this particular district has become something like a cullender, and baffles the art of man in keeping up the roads and means of communication on the surface. At Winsford, a few miles from Northwich, the development of the phenomena has been sudden and surprising. For about 2½ miles in length by 1 mile in breadth the surface is visibly sinking. The canal near the front of the landslip has already gone down 10 feet. At the Winsford end the subsidence is backing down to the town. The Winsford docks have already gone down about 10 feet, and the bridge over the Weaver has again been raised to give height for the passage of boats. In the intermediate parts in the valley of the Weaver a large mere called "The Flashes" is being formed, whilst on the high ground the land is being torn into furrows and holes. The Ordnance Map of 1842 shows the extent then covered with water. The area is now more than doubled. Numerous other landslips and subsidences certainly give the impression that the salt districts are anything but pleasant ones to live in, as the inhabitants can hardly be said to have "fixed residences," while nature, animate and inanimate, seems more or less generally incrusted with a mixture of white from the salt, and black from the coal used in its manufacture.

The buildings in all towns and villages in the immediate vicinity of salt works suffer more or less from the subsidence of the land; but in no place is this more curiously and painfully illustrated than in Northwich. This little Cheshire town was visited by the writer of this Handbook a few years ago, when he was gathering information in reference to salt manufacture, and a very vivid impression was left upon him. Northwich has a somewhat doleful aspect, almost everything being out of the perpendicular or horizontal, as the case may be. A sober visitor, as he walks along the streets, might almost fancy he was suffering from some ocular delusion. It would only be to a person in a state of inebriety that the place would look natural. Indeed, the houses and buildings themselves look inebriated, and tumbling about like a set of drunken men. One is leaning forward, and threatens to tumble into the street, while another is reeling backwards, and suggests the possibility of its eventually falling into the back garden. Then you may see two houses divided by a narrow passage, which have subsided sideways towards each other, and both are apparently kept from falling by the mutual support they receive from the meeting of each other's roofs; or two others, which once were in amicable and perpendicular relation to each other, apparently endeavouring in a hostile spirit to make the gap between them as wide as possible. In more than one place a main street has become widened by some feet, the lines of houses having gradually and modestly withdrawn themselves some distance from the road and pathway. In one instance of this kind the proprietor of the newly-obtained frontage asked the Local Board for the value of the land, which they claimed under the circumstances as town property. The request was refused; but it is a nice point, if ever it comes to trial. Houses are constantly getting into such a state, that it is necessary to pull down and rebuild them, after "washers," "shaps," "face plates," "bolts," and other expedients, together with shoring up, have been resorted to for years. As an instance of the rapidity with which a building will

become untenable may be mentioned the Town Hall, which had to be abandoned not many years after it was built. Again, houses which have been built on rigid wooden frames, and, like Swiss châlets, with much wooden framework in their construction, have frequently to be raised up bodily two yards and more by means of jacks. Experience has recently taught the Northwichians that the best plan is to build on wooden sills and with wooden framework. With such constant work of building up and pulling down, repairing and strengthening, Northwich must be a very Elysium of builders. The most notable instance of subsidence is a cottage which in the memory of many living persons has sunk so deep into the earth, that what were once the bed-rooms on the first-floor are now the sitting-rooms on the ground-floor, the wall between the windows having been knocked through to make a new door. The top of the old door and windows of the ground-floor are now just visible above the ground, and probably the old sitting-rooms are now used for cellars. It sometimes happens that the subsidence of the earth takes place very rapidly, and buildings have been engulphed with hardly a minute's notice. A few years ago a steam-engine and eight men were swallowed up, and scarcely a trace of the accident left, with the exception of the depressed earth. A cottage and some women were similarly entombed, and where the building stood there is now a pond, in which at the time of the writer's visit ducks were happily sailing about. Cracks also in the earth and in the walls of buildings will very suddenly present themselves. People in bed often hear the bricks "grumping," and instances have been known of a light being blown out by the wind entering at a sudden crack in the walls. Cracks also will sometimes open in gardens and in the streets of from 12 to 20 feet deep, so that it is actually dangerous to walk in a dark place by night, risking, as one would, a sprained ankle or some worse accident. It is no exaggeration to say that, with the exception of the case of newly-built houses, there is hardly a level floor in the whole of the town.

And yet, notwithstanding this highly uncomfortable state of things, the good people of Northwich are something more than moderately happy and contented. Accidents involving a sacrifice of life so rarely happen, that they do not make themselves miserable on this score. They seem to trouble themselves as little about what is going on below them through the action of water as do the dwellers round Vesuvius about subterranean fires (*suppositi cineri doloso*) over which they have their being. Indeed Northwich, notwithstanding its zigzag appearance, is a well-to-do little town. A good deal of money is made in it, and consequently a good deal spent in it. Property in land and houses, notwithstanding the tendency of each to disappear, is of considerable value, and is dealt in with as much apparent confidence as if it rested on a solid bed of Kentish chalk, or on the thick granite strata of Dartmoor: and the dwellers in the salt districts generally are probably not nearly so nervous as to the instability of their soil, as are just now the good people of Essex in the neighbourhood of Colchester, who have not yet recovered from the effects of the recent earthquake in East Anglia. It certainly is reassuring to the present inhabitants of Northwich to know that their town existed in some form or other in the time of the ancient Britons, by whom it was called *Hellath* or *Hellu Dhu*, the "Black Salt Town;" and that, despite all the subsidences, crackings, and changing aspects of nature, it is likely to continue to exist in some form or other for many generations to come, and supply us at home, and a great part of the world besides, with the indispensable article of salt.

But these disastrous and even alarming displacements of the soil are still going on, as may be gathered from the further Report of Mr. Dickinson in 1881, and from accounts which have come to hand since the beginning of the present year. In the neighbourhood of Winsford some of the main thoroughfares have sunk a considerable depth, and at the present time are being filled up and repaired, and means adopted for the preservation of adjoining property. Many

of the old dwellings of the town have completely disappeared in the ground, and other houses have been erected over them. There is a space left vacant in the market-place, where a whole row of houses have entirely sunk beneath the surface. Close to the Market Hall there are buildings which have subsided to half their original height, and rooms that were once bedrooms are now shops on the line with the street. In one case a draper has his shop over his old bedroom. Since the Royal Oak Hotel was built eight years ago, it has had to be lifted twice by hydraulic jacks. The Town Hall had so much sunk, that a year or two ago it had to be raised 8 feet. A great deal of the subsidence has occurred in the neighbourhood of Christ Church. In fact the church is on anything but a "sure foundation." Four years ago the structure was condemned, and it was taken down and replaced with a building of strong timber and brickwork. Notwithstanding the precautions, this, too, soon began to be affected by the subsidences, and during the past two or three years a portion of it has had to be raised no less than seven times, to preserve its equilibrium. The old Market Hall is now beneath the surface of the ground, and upon its place is a new one. The history of the old building is unique. On its erection a flight of steps had to be ascended to gain the entrance. As the subsidence continued, the steps gradually disappeared, and in a few years entrance could only be obtained by a descent. It went on sinking, until it completely disappeared beneath the surface, having sunk altogether no less than 27 feet. On account of the continual subsidences the Weaver school premises are sinking, and the authorities are expected shortly to condemn them as unsafe. Breakages of mains, pipes, &c., caused by the sinking of the land, are constantly going on, causing much inconvenience and very considerable expense.

Indeed, such has been the damage done to land and buildings in the Salt District of Cheshire during the last few years, that it is not surprising that a large number of owners, who did not directly receive any benefit from the

salt manufactures, should come to gradually feel it an injustice that damage should be done to their property without some compensation. But all through the agitation, which assumed a definite form some years ago, the great difficulty was to suggest any equitable basis on which compensation should be made. Eventually a private Bill was promoted by certain property owners in the Northwich and Winsford districts in the session of Parliament 1881, entitled "A Bill to make Provision of the Assessment, Levy, and Application of Compensation for Damage by Subsidence of Land in the Salt Districts of Cheshire, and for other purposes." The Preamble set forth "That great quantities of brine for the manufacture of salt are annually raised by pumping from the beds of rock-salt. That such beds form the natural support of the superincumbent strata, and of the surface of the ground. That by the pumping the beds of rock-salt are continually being dissolved, and the natural support withdrawn with great injury to the surface and property. That the brine so pumped is for personal profit, and for purposes of sale and manufacture, and is not exclusively derived from beds of salt owned by the pumpers, but is frequently in great part derived from what belongs to others who receive no payment. That from the difficulty of proving whence the brine pumped at any particular pit is drawn, or by what pump the damage is done, it is impracticable to obtain any remedy by legal proceedings. And that it is just and expedient that provision should be made whereby compensation could be obtained for such damage." It was further proposed that a sum not exceeding 3*d.* should be paid for every ton of salt in brine raised or obtained in the district, it being considered that this would suffice, and would not materially affect the salt trade or expose it unduly to competition, and that a Board representing various interests should be constituted with powers to ascertain the amount required, raise the money and distribute it and act generally. The Bill was strongly opposed by the salt manufacturers, and the whole case was elaborately argued by eminent Parliamentary counsel before

a Committee of the House of Commons, which eventually announced the unanimous opinion that the "Preamble was not proved."

Thus the matter is left as it was, and for the present at least the salt trade is saved from an interference which might seriously cripple if not ultimately ruin an important industry. Unless some definite legislation to the contrary is effected, brine will continue to be treated under the same rules as water. Natural flows of water on the surface may be used as they pass, but not fouled, nor turned into another shedding; and below ground, where water is not in some defined channel, it belongs to the person in whose well, shaft, or working it is found. Any number of neighbours' wells may be drained into a properly worked mine with impunity, "the miner getting what he does not want, and the neighbours losing what they greatly prize." Brine is claimed in the same way, and is taken to belong to the person in whose digged well, shaft, or working it is found, no matter where it comes from. This is in accordance with the firmly established principles of Common Law concerning the flow of subterranean liquid; and any modifications of them to meet this particular case would be generally considered an injustice to the salt trade, and likely to injuriously affect the consumers of salt. Mr. Dickinson gives in his Report of 1881 a full history of this complicated case, arranging the *pros* and *cons* in a most interesting and impartial manner, and concludes with the following sentence:—"The failure to obtain a settlement of the question may be regretted, but, considering all the grounds upon which the case was combated, no one can reasonably quarrel with the decision of the Committee. It may have to end as it stands, or possibly upon some equitable basis an arrangement may be effected."

Taking the returns of salt production in 1881, the following interesting but somewhat alarming calculation has been made by Mr. Dickinson in his Report of 1881:—"The admitted annual production of 1,600,000 tons of white salt in Cheshire, and of about 220,000 in Worcestershire, and

say 4000 in Staffordshire, beside last year's production of 166,740 tons of rock-salt in Cheshire, and 30,891 tons in Ireland, is drawn from the ground. The production of white salt from brine in Cheshire alone, accompanied with say 25 per cent. of waste in production, working and transit, and averaging each cubic yard of rock-salt dissolved to weigh 33 cwt., represents 1,212,000 cubic yards of rock-salt, or about 250 statute acres one yard in thickness, annually pumped out of the ground; the rock-salt produced representing 21 acres or more.

Subsidences are also taking place in the Worcestershire Salt District, and the town of Droitwich has already suffered to some extent as Northwich has, but it would hardly be within the scope of this Handbook to enter further into the matter. It has been introduced as likely to be of interest to general readers, and as an illustration of the consequences involved by the consumption of such a simple article as common salt.

CHAPTER VIII.

SALT-LORE.

HAVING now briefly considered salt as a condiment, the sources of its supply, and its manufacture for our ordinary use, it seems but appropriate to add some remarks on what may be called its lore. On this a volume of no small dimensions might be written without exhausting the subject, as in almost all nations from the earliest times salt has been associated with a variety of religious, social, and other customs, and many superstitions; while its symbolical significance has been almost coexistent with its practical use.

Salt-lore would naturally begin to accumulate with its earliest use, which, if the suggestions made in Chapter I. be correct, may be taken to be coeval with man. The idea of holiness was attached to salt from the very earliest times, as may be gathered from several ancient mythologies. The Germans called salt the special "gift of God," and there was an old belief among them that where salt water was, there heaven was near, and that prayers were better answered when offered near salt. The Old Testament contains many mentions of salt, which refer to ancient customs and associations connected with it. Thus its use is emphatically enjoined in the Levitical Law:—"Every oblation of thy meat offering shalt thou season with salt; neither shalt thou suffer the salt of the covenant of thy God to be lacking from thy meat offering: with all thine offerings thou shalt offer salt." (Lev. ii. 13). According to some of the Rabbinical commentators, the salt used in the sacrifice implied that purity of mind and sincerity of feeling necessary in all worshippers who desired to offer an

acceptable sacrifice to Jehovah. Others assert that the salt was an emblem of the fidelity of the covenant which God had established with His chosen people. But certain it is from the context that the use of salt with sacrifice and offering was based on its antiseptic properties. In verse 11 it is distinctly forbidden to use leaven with any meat-offering or burnt-offering. There is an evident antithesis between the interdiction of leaven and the commanded use of salt. Leaven, however useful, was regarded in its principle as a species of putrefaction, since that which is leavened very soon spoils in the warm regions of the East, whereas unleavened bread may be kept any length of time. At the present day, the cakes or bread offered in the ceremonies of the Hindoos are always unleavened, although leaven is in bread used for domestic purposes. On the other hand, the well-known preservative qualities of salt rendered it symbolical of incorruption and soundness, and therefore its adoption in the offerings was dictated by the same considerations, whether physical or figurative, which precluded the use of leaven. So far from the use of salt here being, as some think, in opposition to pagan practices, it is certain that salt was used by Greeks and Romans and other nations at a very early period in their sacrifices and oblations. Homer expressly mentions "sacred salt" as strewed upon sacrifices, and also speaks of offerings of salted cakes. In fact, salt occupies a conspicuous place in the heathen sacrifices both with and without blood. In the former, not only was a salted cake put on the head of the victim, but salt, together with meal, was strewed on the victims, the fire, and the knives. The custom is alluded to in Mark ix. 49:—"Every one shall be salted with fire, and every sacrifice shall be salted with salt."

The salt used in the Temple was rock-salt, and considerable quantities were stored up in the Temple for use. It has been suggested that much of the rock-salt would naturally be mingled with clay or sand, and, being exposed to the air, some of the salt would absorb moisture, and thus waste away. The salt being thus deprived of its savour,

was scattered over the pavement, to render it less slippery in wet weather, or it was thrown out to mend the roads. To this it is thought that our Saviour alludes when He says to His disciples—"If the salt have lost his savour, wherewith shall it be salted? it is thenceforth good for nothing, but to be cast out, and to be trodden under foot of men" (Matt. v. 13). Some think that the Temple salt may have been brought from the Valley of Salt, because Maundrell, in his narrative of a journey to the Euphrates, says that about four hours' journey from Aleppo there is a precipice of salt, and that the part exposed to the sun and rain and air, though it had the sparkling of salt, yet had perfectly lost its savour. Another suggestion mentioned by Alford in his Greek Testament is that a kind of bitumen from the Dead Sea was called "Salt of Sodom," and was used to sprinkle the sacrifices in the Temple; which salt was utilized, when its savour was gone, to strew the Temple pavement, that the priest might not slip. Sir Lyon Playfair has suggested that in this passage we should read "petroleum instead of salt." Visitors to the Health Exhibition may see at the stand of Messrs. Bumsted and Co. an actual sample of salt which has "lost its savour," and another sample taken from the same source which has *not* lost its savour. Mr. John Bumsted kindly communicated with the writer in reference to these samples, and the following is an extract from his interesting letter:—"Sea-salt is not pure salt, containing, as you will see by analysis, with 89 parts of pure chloride of sodium, several other substances—some of them soluble and some not. All of course were dissolved in the sea-water except possibly invisible and transparent organisms, but my notion is that some of them may have changed their character after lying combined with the salt and exposed to the air, so that in fact they become insoluble. So we come to the salt that has lost its savour. Take a bag of salt, as per sample enclosed marked 'salt,' put it in a pail, pour fresh water on it, and run off the brine. Your salt will get 'small by degrees and beautifully less;' continue the process, at last you will have a sediment which will not dissolve,

and will not taste salt, in fact, salt which has lost its savour. See second sample.—This is only a curiosity, and this is how it came about. In *Good Words*, for February, 1884, Sir Lyon Playfair contributed an article on petroleum (I think it was), and he gave some reasons for thinking that in St. Matthew 'petroleum' and not 'salt' is meant, for, as the learned Professor says, 'Salt does *not* lose its savour.' Of course our English salt does not; you may crush it all away and you will find nothing; it is perfectly soluble. But I believe the salt that St. Matthew ate was like the salt made at Lisbon, Cadiz, Marseilles, and all round the sea in tropical countries, from sea-water. I am sorry to say I really don't know if salt is obtained from the *Dead Sea;* if it is, its waters may be purer or otherwise than sea-water. But I think my specimens show that if a great heap of salt like my sample No. 1, say some hundreds of tons, were to be exposed to a heavy downpour of rain for a few days, it would be the most natural thing in the world to find at the margin of the heap a quantity of salt which had lost its savour, and if 'the Master' were passing by at the time He could see the lesson and point it. This is the history of 'salt that has lost its savour.' My father has known this for a long time, but I believe it has not been observed by any one else, and in defence of the common-sense criticism of the New Testament, I venture to make this explanation. My samples have created a good deal of interest."

There are many other interesting passages in Scripture connected with salt. The prophet Elisha being desired to sweeten the waters of the fountain of Jericho, required a new vessel to be brought to him, and salt therein (2 Kings ii. 20). He threw this salt into the spring, and said (v. 21), "Thus saith the Lord, I have healed these waters; there shall not be from thence any more death or barren land." The "Valley of Salt" is placed by some writers to the south of the Dead Sea toward Idumea, because it is said (2 Sam. viii. 13), that David smote the Syrians in the Valley of Salt; and also that Abishai (1 Chron. xviii. 12),

"slew of the Edomites in the valley of salt eighteen thousand." The reference to Lot's wife and the Dead or Salt Sea are well known. We read too of the "Covenant of Salt" in Numbers xviii. 19.—"All the heave-offerings of the holy things, which the children of Israel offer unto the Lord, have I given thee, and thy sons and thy daughters with thee, by a statute for ever: it is a covenant of salt for ever before the Lord unto thee and thy seed with thee." And again, "Ought ye not to know that the Lord God of Israel gave the kingdom over Israel to David for ever, even to him and to his sons by a covenant of salt?" (2 Chron. xiii. 5). Some commentators explain this covenant by asserting that salt is an emblem of perpetuity, especially as there is in the East a kind of salt so hard as to be used for money; but others suppose that the covenant of salt refers to an agreement in which salt is used as a token of confirmation. Federal engagements among Eastern tribes are to this day ratified with salt; and oaths taken on salt are considered the most binding of all. The Hindoos swear by their salt, and during the great Indian mutiny the Sepoys were often held in restraint by being reminded that they had sworn by their salt to faithfully serve the Queen of England. Salt was often eaten on bread as a confirmation of a solemn promise given. Thus salt came to be the symbol of the fidelity due from servants and officers to those who maintained them: which will account for the governors of the provinces beyond the Euphrates writing to the King Artaxerxes, "because we have maintenance from the King's palace," &c. (Ezra iv. 14), which in the Chaldee is, "because we are salted with the salt of the palace," &c.

Allied to this idea of the sanctity, so to speak, of salt in connection with the making of any promise or compact, was that of its being the symbol and silent expression of hospitality, in the observance of which the common instincts of mankind have ever discovered a peculiar sacredness. Thus we find Cassandra aggravating the crime of Paris in stealing Helen on the ground that he has "contemned the

salt and overturned the hospitable table." Arabs still offer salt as a sign that their guest is safe in their hands; and even the Bedouin robber will not violate the laws of hospitality to one who has once tasted of his salt; the guest being also bound by reciprocal obligations. As an illustration of the strength of this bond, Price in his 'Mahommedan History' gives the following incident:—"Yaakoob, the son of Eb-Leys Es-Suffar, having adopted a predatory life, excavated a passage one night into the palace of Dirhem, the governor of Seestan; and after he had made up a convenient bale of gold and jewels, and the most costly stuffs, was proceeding to carry it off, when he happened, in the dark, to strike his foot against something hard on the floor. Thinking it might be a jewel of some sort or other, he picked it up, and put it to his tongue; and, to his equal mortification and astonishment, found it to be a piece of rock-salt; for, having thus tasted the salt of the owner, his avarice gave way to his respect for the laws of hospitality, and, throwing down his precious booty, he left it behind him, and withdrew empty-handed, to his habitation. The treasurer of Dirhem repairing on the next day, according to custom, to inspect his charge, was equally surprised and alarmed at observing that a great part of the treasure had been removed; but on examining the packages that lay on the floor, his astonishment was not less to find that not a single article had been conveyed away. The singularity of the circumstance induced him to report it immediately to his master; and the latter causing it to be proclaimed through the city, that the author of this proceeding had his free pardon, further announced that, on repairing to the palace, he would be distinguished by the most encouraging marks of favour." It is further stated that Yaakoob availed himself of this invitation, relying upon the promise, which was fulfilled to him, and from this period he gradually rose in power, until he became the founder of a dynasty. In a less sacred way perhaps, but with much significance, an Abyssinian gentleman carries a piece of salt in his pocket,

and takes it out, and offers it to a friend to lick as a mark of respect and esteem.

As salt used in moderate quantities conduces to the fertilization of land, and was supposed by some to conduce to prolificness in animals, it came to be considered a symbol of desired production; but *per contra*, as in districts where it forms the chief ingredient in the soil a barren desert is the result, it was taken to signify sterility and desolation. Thus, when Abimelech took the city of Shechem, he destroyed it and sowed the place with salt, that it might always remain a desert (Judges ix. 45). Zephaniah (ii. 9) thus threatens the Moabites and the Ammonites—"Surely Moab shall be as Sodom, and the children of Ammon as Gomorrah, even the breeding of nettles, and salt-pits, and a perpetual desolation." And in the description of the wild ass and his haunts in Job xxxix. the "barren land" of verse 6 is in the margin "salt places."

Another well-known metaphorical application of salt is that to the mental faculties. Pliny, when arguing that human nature cannot exist without salt, says that it is so much an element of life that, passing from bodily sensation, it became from a very remote antiquity a metaphorical term for the pleasures of the mind. Salt is agreeable to the palate, and is therefore transferred to the mental taste. It is synonymous with whatever presents itself as piquant, lively, or agreeable to our mental faculties; and further signifies more solid food for the mind which shall keep it pure and wholesome. It is in these senses that Pliny calls Greece *Sal gentium*, because it was to Greece that the whole world was indebted for intellectual sustenance. In a still higher sense, our Saviour, in the passage above quoted (Matt. v. 13), says to His disciples, "Ye are the salt of the earth," i.e. the means of preventing or curing the growth of that corruption which prevails in it, and seasoning men's minds with the salt of true wisdom—*Sal sapientiæ*. In a somewhat similar sense St. Paul says to the Colossians (iv. 6), "Let your speech be alway with grace, seasoned with salt;" though, judging from the context, "salt" here

may have the further idea of "sound judgment," and also of "point," spiritual freshness, and piquancy. With the Latins the metaphorical meaning of *Sal*, *Sales*, *Salsa*, was mainly confined to wit and witticisms and "clever" talk, much in the same way as we still use the expressions "Attic salt" and "sallies." But the words also were used of ill-tempered, biting sarcasm. The following story smacks both of the material and Attic commodity. Three Capuchin friars, travelling, arrived at an inn, but so poorly was it supplied, that a single egg and one pinch of salt was all they found there. At first they disputed the prize, but at last agreed it should become the property of the one who quoted from his breviary the most appropriate phrase. Accordingly the first took it and struck off the top, saying, "*Sic conteret caput tuum;*" the second received it, and, putting in the salt, said, "*Accipe sal sapientiæ;*" it was then passed on to the third, who swallowed it up, saying "*Intra in gaudium Domini.*"

But salt has also a metaphorical application in a coarser sense, signifying the strong passions associated with youth. Thus, in Shakespeare, Iago says, "Hot as monkeys, salt as wolves in pride" (*Othello*, iii. 3). The Duke calls Angelo's base passion his "salt imagination," because he supposed his victim to be Isabella, and not his betrothed wife, whom he was forced by the Duke to marry (*Measure for Measure*, v. 1); and Shallow says, "Though we are justices, and doctors, and churchmen, Master Page, we have some salt of our youth in us." (*Merry Wives of Windsor*, ii. 3).

Passing on to social and other customs and superstitions connected with salt, we find that it was associated in many different parts of the world with witchcraft and magic, especially among Teutonic nations. An interesting suggestion is made in reference to this in Stallybrass's *Teutonic Mythology*. Referring to the salt-springs, which we know from Tacitus and others were highly valued by the early Teutonic tribes, he says: "Suppose now that the preparation of salt was managed by women, by priestesses; that the salt-kettle, salt-pan, was under their care and

supervision, there would be a connection established between salt-boiling and the later vulgar opinion about witchcraft: the witches gather, say on certain high days, in the holy wood, on the mountain, where the salt-springs bubble, carrying with them cooking vessels, ladles, and forks, and at night their salt pan is aglow . . . As Christians equally recognised salt as a good and needful thing, it is conceivable how they might now, inverting the matter, deny the use of wholesome salt at witches' meetings, and come to look upon it as a safeguard against every kind of sorcery. For it is precisely salt that is lacking in the witches' kitchen and at devils' feasts, the Church having now taken upon herself the hallowing and dedication of salt." It is curious that salt was both used in magic, and to defeat magical purposes. In reference to the later use, Aubrey says, "That salt is inimique to the Evill spirits is agreed upon by the writers of magick; as also perfumes, which is the reason they were used in their temples and sacrifices. Holy water is water wherein fine white salt hath been dissolved." Salt is used, according to the Roman Catholic ritual, in the fabrication of "Holy Water."

Salt superstitions and customs seem specially connected with the treatment of children. It would appear from Ezekiel vi. 4, that the Jews "salted" their infants in some way or other immediately after birth; but whether this was done from a belief in the medicinal value of the outward application of salt to their bodies, or as a religious ceremony, or simply from some superstition, it is difficult to conjecture. In the service of the Latin Church a pinch of salt (*parva mica*) is put into the child's mouth at baptism, the priest saying "Receive the salt of wisdom (*accipe sal sapientiæ*), and may it be a propitiation to thee for eternal life." Aubrey tell us that "when children shaled their teeth, the women used to wrap, or put salt about the tooth, and so throw it into a good fire," a custom said still to linger in Yorkshire. Dyer tells us in his *English Folk-lore* that when a child first leaves its mother's house, it is in Leicestershire Lancashire, and other counties presented with salt.

In some parts of Scotland a new house, or one which a new tenant was about to enter, is sprinkled with salt to bring luck; and those who endeavour to be first to enter friends' houses on New Year's morning often bring bread and salt, in lieu of a present which the "first foot" is supposed to offer. But salt is not only used as a lucky thing, it is also employed in uncanny rites. Traces of this use we perhaps see in all cases where salt is burnt. For example, in the "salt spell," as it is called, a pinch of salt must be thrown into the fire on three successive Friday nights while these lines (Henderson's *Folk-lore of the Northern Counties*) are repeated —

> "It is not this salt I wish to burn,
> It is my lover's heart to turn,
> That he may neither rest nor happy be,
> Until he comes and speaks to me."

The people in North Lincolnshire hold the belief that if salt is not thrown into the fire before churning is commenced, the butter will not come. In the North-East of Scotland it is unlucky that milk should boil over the edge of the pot and run into the fire, as it diminishes the quantity of milk given by the cow, and salt should immediately be thrown into the fire to counteract the mischief. In the West of Scotland, if the evil eye had been bathed with salt and water, and had tasted the mixture, it was thrown "into the hinder part of the fire," the "skilly" neighbour who superintended the operations saying at the same time, "Guid preserve frae a' skaith." Probably, as the repetition backwards of the Lord's Prayer was said to raise the devil, so the unnecessary destruction of the life-necessary salt was equivalent to a propitiation of the powers of evil, Christian or pagan; salt in its proper use being esteemed holy.

It was a very common custom to place a plate of salt on the breast of a corpse after it had been laid out, the idea being that Satan, and evil spirits generally, hated salt, because it was an emblem of incorruption and immortality.

The practice still exists in some places, as also that of putting salt within the coffin. In the Highlands of Scotland it was a common custom to place on the breast of the deceased a wooden platter, containing a small quantity of salt and earth, separate and unmixed; the earth an emblem of the corruptible body—the salt an emblem of the immortal spirit. Herrick expresses the idea in these lines:—

> "The body's salt the soul is, which, when gone,
> The flesh soone sucks in putrefaction."

In some districts there was the further belief that salt laid on the breast of a dying person caused death itself to be more easy. To sprinkle meat with salt was thought by some efficacious in driving away the devil; and a quaint old divine speaks of one of unstable character as "loving no salt on his meat, for that is a sign of immutability."

We probably derive the well-known superstition as regards the bad luck attending spilling salt from the Romans, who considered it a bad omen if the salt fell from the head of a victim. This superstition is almost universally held among us now; or, rather, the custom of throwing some of the spilt grains over the left shoulder as a counter-charm is as universally observed, as of refusing to pass under a ladder, and of wishing when a piebald horse is seen. But these observances, though so generally practised, are seldom regarded as serious. According to orthodox believers in omens, the counter-charm of throwing salt over the left shoulder is useless unless it be done three times, with the use of the words "go to the devil," each time. In Leonardo da Vinci's famous picture of the Lord's Supper, Judas Iscariot is known by the salt-cellar knocked over accidentally by his arm. We all remember among the list of omens the line—"The salt was spilled, to me it fell": and old German housewives will tell a child that upsets salt that it will weep as many tears as there were grains spilt. The

Dutch still see in an overturned salt-cellar the symbol of a shipwreck.

The expressions "sitting above," and "below the salt" are familiar. The time-honoured custom in grand families of placing a massive piece of plate, called the salt-vat, or "foot," on the middle of the table was one that formerly obtained in France as well as in England and Scotland, the guests being seated above or below the vessel according to their several ranks.

> "Thou art a carle of mean degree;
> Y^{e} salt doth stande twain me and thee,"

says an old English ballad, showing that sitting above the salt was the mark of a gentleman, or of a man of good connexions; while, to sit beneath it indicated a humble station in society. This distinction also extended to the fare; the wine frequently circulating only above the salt-cellar, and the dishes below it being of a coarser kind than those near the head of the table. It is, however, but right to add that some antiquarians have rather questioned all that is usually supposed to be implied in the phrase "below the salt." According to these critics, the sitting above or below the salt meant nothing more than having a place at the upper or lower end of the table, the relation which one's seat was said to bear to the salt being merely accidental, from the fact that the vessel containing it was the centre object. But the ordinary interpretation seems fully borne out by reference to various historical authorities; and the custom must be considered as one which debased salt from its high symbolism of hospitality to being used as a means of making invidious distinctions. In *Cynthia's Revels* by Ben Jonson, we hear of a character who takes no notice of any ill-dressed person, and never drinks to anybody below the salt. One writing in 1613 about the miseries of a poor scholar in the houses of the great, says, "he must sit under the salt—that is an axiom in such places." Even, strange to say, the clerical preceptor of the children had to

content himself with this inferior position, if we are to trust to a passage in Bishop Hall's satires—

> "A gentle squire would gladly entertain
> Into his house some trencher-chapelaine,
> Some willing man that might instruct his sons,
> And that could stand to good conditions:
> First, that he lie upon the truckle-bed
> Whiles his young master lieth o'er his head;
> Second, that he do, on no default,
> *Ever presume to sit above the salt;*
> Third, that he never change his trencher twice," &c.

A Scotch noble, again, writing in 1680 about his family and its old neighbours, introduces a derogatory allusion to the self-raised son of one of those against whom he had a spite, as coming of a family who, in visiting his (the noble's) relatives, "never came to sit above the salt-foot."

Proverbs, sayings, and metaphorical expressions are found in our own and other languages connected with salt. The expression "not worth his salt" is probably connected with the word *salarium*, the salt ration, or salt-money (*salarium*) of the Roman soldiers before alluded to; and the meaning of "He will not earn salt for his porridge" is sufficiently obvious. The Eton "Montem," now abolished, suggests that the word "salt" was sometimes used almost as an equivalent for "money," the captain of the school receiving on the little eminence at Salthill, near Eton, the "salt" or money collected on his behalf. But if this suggestion will not hold good, there is still a connection between salt and the Eton Montem in the fact that a certain number of the boys denominated "salt-bearers," attired in fancy dresses, scoured the country on the morning of Montem day, and levied a tribute of money from hundreds of persons who came, according to custom, to have tribute demanded of them. According to the ancient practice, the salt-bearers were accustomed to carry with them a handkerchief filled with salt, of which they bestowed a small quantity on every individual who contributed his quota to the subsidy. The origin of this

custom of distributing salt is obscure, but it would appear to have reference to those ceremonies so frequently practised at schools and colleges in former times, when a new-comer or freshman arrived, and, by being "salted" and after a variety of ceremonies more amusing to his companions than himself, was admitted to a participation with the other scholars in their pastimes and privileges. To take anything "*cum grano salis*" is to use caution in accepting a statement, or "to take a liberal discount off it," the idea apparently being that as salt is sparingly used as a condiment, so truth is sparingly scattered in an exaggerated statement or report. Then we have salt used metaphorically in a bad sense. "To salt an invoice" is to put the extreme value upon each article, and even something more, to give it piquancy and raise its market value. The French have the same expression, as *Vendre bien salé*, "To sell very dear;" *Il me l'a bien salé*, "He charged me an exorbitant price;" and generally *saler* is to "pigeon" one. Shakespeare and other old poets and writers use the word salt in a variety of metaphorical expressions.

Thus from whatever point of view we regard "Common Salt," it abounds with material for reflection; and it may almost be said that its historical associations, symbolic usages, and the customs and beliefs connected with it, are as interesting as its gastronomic, culinary, and medicinal properties are invaluable. Salt in some way or other confronts us, so to speak, at every turn; and there is little exaggeration in the old saying

SAL SAPIT OMNIA.

PART II.

CHAPTER IX.

MUSTARD.

SEVERAL botanically distinct species of pl
cally similar in possessing powerful and pec
tastes, arising from the presence in them of
the "radical" of the essential oils cont
Instances of this are garlic, onions, horse-radish
and it is interesting to notice that without
of the close chemical relations among the pla
different races of men, in different parts of
long selected and largely used them as cond
food. The Englishman, to a certain limited
his onion, and the Frenchman mildly flav
savoury dishes with a touch of garlic or
Russian soldier fries his black bread with
And mustard is almost everywhere a favour
Further considerations will probably show th
pounds of allyl exercise a peculiar physi
upon the system, by which certain of its natur
allayed, and its general comfort promoted.

Mustard has its historical interest as
domestic use. It was probably first used

forefathers mixed it with honey, vinegar, and wine, as a condiment, but the first actual record of the use of mustard in England seems to occur in the household book of the Duke of Northumberland in the reign of Henry VII., where it is stated that 160 gallons of mustard seed was the allowance per annum for his retainers and servants. It does not appear that the seed was manufactured in those days, but was brought to table whole, where it was bruised and mixed with vinegar according to taste. Gerarde, the celebrated herbalist, tells us that garden mustard (the white seed) had not become common in the time of Elizabeth, but that he had distributed it to various parts of England to make it known. He remarks—"mustard makes an excellent sauce, good to be eaten with gross meats, either fish or flesh, because it promotes digestion and sharpens the appetite.

Prior to the date of about 1720 there was no such luxury as mustard in its present form at our tables. At that time the seed was coarsely pounded in a mortar, as coarsely separated from the integument, and in that rough state prepared for use. In the year mentioned it occurred to an old woman of the name of Clements, residing in Durham, to grind the seed in a mill, and pass it through the several processes which are resorted to in making flour from wheat. The secret she kept to herself for many years, and, in the period of her exclusive possession of it, supplied the principal parts of the kingdom, and in particular the metropolis with this article. George I. stamped it with fashion by his approval. Mrs. Clements regularly twice a year travelled to London and the principal towns throughout England for orders; and the old lady continued to make a considerable amount of money. From this woman residing in Durham, it acquired the name of "Durham mustard."

Like salt, mustard has given occasion to many proverbial sayings, and metaphorical expressions, both among the ancients and moderns, its heat being suggestive of "hot" temper and so forth. Thus the old Greeks spoke of an

angry man as "looking mustard" (σιναπι βλεπων); and the French still have the metaphor of "putting mustard up the nose" for the process of mentally irritating. There is not as much poetry about mustard as about salt, but it is frequently introduced by our old dramatists, for instance by Shakespeare in *As you Like it* (i. 2.), *Taming the Shrew* (iv. 3) and in *Henry IV.* (ii. 4), where Falstaff speaks of "Tewkesbury mustard."

Botanically the mustard is an annual "cruciferous" plant having several varieties, but best known in the form of *Sinapis nigra*, or black mustard, *Sinapis alba*, or white mustard, and *Sinapis arvensis*, or charlock. The two former are, however the only kinds actually cultivated for use as a condiment in this country. Black mustard, which constitutes the chief ingredient in edible mustard, is a plant which is found wild in all but the most northern parts of Europe, as well as in North Africa, Asia Minor, Mesopotamia, the Caucasus, India, Siberia, China, and naturalized in North and South America. It is cultivated extensively in Alsace, Bohemia, Holland, Italy, and on the richest alluvial soils in England, notably in Cambridgeshire, Lincolnshire, Yorkshire, and formerly Durham. It requires a very rich soil for its development in the greatest excellence, and great care is necessary in the planting and harvesting of the seed. The great aim of the grower is to produce reddish brown seed without any admixture of grey, which is attributed to rain. If unfavourable weather occurs as the time of ripening and harvesting the quality is much deteriorated, and the market value is reduced to a considerable extent. The seed of the *S. nigra*, which is of a reddish or blackish-brown colour, is very small in size, and yields in comparison with white mustard a much smaller proportion of flour when ground.

White mustard is the plant which is now largely grown as a forage crop for sheep, and also as a bulky organic manure to be ploughed in for grain crops. It is much more widely distributed than the black variety, and may be grown on almost all kinds of soil; nevertheless the finest

qualities of seed are grown in the alluvial soils of Essex, Cambridgeshire, and Lincolnshire. Holland also produces both kinds of seed, of fair quality; but the chief places of production for really fine quality are the English counties mentioned above. The seed of the white mustard is yellow.

To the above species may be added *Sinapis juncea*, the brown or Indian mustard (rai) which is sometimes offered in London sales for black mustard. It is extensively cultivated in India, Central Africa, and other tropical countries. It flourishes particularly well in the saline soils of South Russia and the steppes lying North-East of the Caspian, some 800 tons of seed being annually prepared for table at Sarepta, in the government of Saratov.

It is very difficult to arrive at an estimate of the quantity of mustard seed produced and consumed annually, but it is certain that many thousands of acres in England are under cultivation with this plant for the purpose of seed. The yield on the average may be taken at about three quarters per acre, and four quarters would be an exceptionally good crop. The money value varies in the case of brown seed to a great extent from year to year, according to the season and the state in which the crop has been secured, but the average in recent years may be considered to be 13*s.* to 15*s.* for black, and 9*s.* to 11*s.* per bushel for white seed.

Mustard, from a chemical point of view, possesses very great interest, the composition both of the brown and white seed being peculiar and of a very complicated nature. They both contain a large proportion of fixed oil (about 36 per cent.). This oil is of a bland character, very much like rape oil, and possesses no pungency. The brown seed contains a substance known as myronic acid, which exists in combination with potash, and also another body called myrosin. When the flour of brown mustard seed is moistened with cold water a singular change takes place —the myrosin, which seems to act as a kind of ferment like disastase in malt, re-acts upon the myronate of potash and develops the volatile oil of mustard, an excessively pungent liquid, a mere drop of which applied to the

skin raises a blister in a moment. Thus the pungency of table mustard is the result of the peculiar fermentation which takes place immediately a sufficient quantity of water is added.

White mustard contains practically no myronic acid, but an acrid substance known as sinalbin, which is but slightly present in the brown seed; and hence we see a strong reason why in the mustards of commerce the farina of the two species should be blended together, as it is on the volatile oil and the acrid and somewhat bitter salt that the pungency and acridity of mustard depend. Of the two active principles the volatile oil is by far the more important, and hence the seed of the brown mustard possesses the greatest commercial value.

The following are the analyses of the farina of brown and white mustard as given by Dr. Hassall :—

BROWN MUSTARD FARINA.

Water	4·845
Fixed oil	35·701
Myronic acid	4·810
Myrosin and albumen	29·536
Acrid salt	3·588
Cellulose	16·765
Ash	4·725
	100·000
Volatile oil	1·271
Nitrogen	5·068
Sulphur	1·413

WHITE MUSTARD FARINA.

Water	5·360
Fixed oil	35·768
Acrid salt	10·983
Myrosin and albumen	27·484
Cellulose	16·295
Ash	4·110
	100·000
Nitrogen	5·285
Sulphur	1·224

The mustard of commerce, or table mustard, is one of those articles which has given rise to considerable discussion under the Adulteration of Food and Drugs Act of 1872; and more recently under the "Sale of Food and Drugs Act" of 1875. On the one hand it has been contended that pure flour of mustard only should be sold to the public. This view has been strongly advocated by prominent food analysts; while, on the other hand, men occupying equally high scientific positions see no reason to object to mixtures of mustard flour with suitable proportions of wheaten or rice flour, to moderate the somewhat coarse and bitter flavour of pure mustard, and to assist in preserving the article from decomposition, both in the dry and wet form, since perfectly pure mustard is very prone to undergo a change by variation of temperature and exposure to air which by no means adds to its value as a condiment, in fact, renders it offensive. The same authorities also see no objection to the use of turmeric, as a practically innocuous ingredient, which is used almost of necessity to restore or bring up the colour of the added flour to the original standard of the mustard farina. It is argued that in consequence of the presence of the pungent volatile oil, a condiment composed only of pure mustard flour, after being mixed for use, turns in a short time to a dark brown colour and becomes decomposed and unfit for use; and that therefore it requires to be mixed fresh every day; and this alone forms an objection in the eyes of most consumers, both on account of the inconvenience and the extra expense. To minimize this ill effect nearly all mustard manufacturers mix a certain proportion of the finest wheat flour, which helps to absorb the essential oil and has also the effect of enabling the mixed condiment to retain its sweetness and colour, and consequently its usableness, twice as long as the "genuine" mustard.

As an argument in favour of the presumed necessity of using some harmless diluent to absorb the excess of oil in table mustard, reference may be made to the practice of the Government Navy Victualling Yard, where rice flour is

used for this purpose, as may be seen in the series of Blue Books published yearly; even ginger has been occasionally used and capsicum invariably, the fact being that pure mustard having any considerable proportion of the flavour-giving brown seed will not bear the climate of the tropics without serious deterioration.

That the sale of such mixed mustard was considered quite legitimate, it is only necessary to refer to the Report of the Select Committee of the House of Commons on the adulteration of food in 1874, where the following summary occurs (page 5):—"Your Committee have had under their consideration the sale of mixed articles of food and condiments; amongst them great prominence has been given to mustard (and cocoa). The evidence tends to show that these articles have been sold pure, as well as mixed with other ingredients to suit the requirements of consumers. And it has also been demonstrated to the satisfaction of your Committee that the compounds are frequently made quite as much to suit the public taste as to increase the profit of the manufacturers, inasmuch as by using a lower quality of mustard seed a pure article may be made at a lower price than some of the mixtures. It is also due to the manufacturer to record that the mixed mustard has long been manufactured at the Deptford Yard for the supply of the Navy. Your Committee therefore come to the conclusion that the sale of such mixtures or compounds is allowable, and indeed needful, to meet the public requirements, provided the fact of their being mixtures is plainly indicated to the purchaser by a legible label or notice conspicuously attached to the outside of each package in which, or vessel from which such mixture is sold.

Clause 6 of the "Sale of Food and Drugs Act" of 1875, before referred to runs thus:—

"No person shall sell to the prejudice of the purchaser any article of food or any drug which is not of the nature, substance, and quality of the article demanded by such purchaser, under a penalty not exceeding twenty pounds; provided that an offence shall not be deemed to be com-

mitted under this section in the following cases; that is to say:

"Where any matter or ingredient not injurious to health has been added to the food or drug because the same is required for the production or preparation thereof as an article of commerce, in a state fit for carriage or consumption, and not fraudulently to increase the bulk, weight or measure of the food or drug, or conceal the inferior quality thereof."

This provision added to the clause is held to cover the manufacture of the mustard of commerce or "mixed" mustard.

Experience has proved that mustard is an article which requires very special management to ensure the best results as to flavour and keeping qualities, chiefly owing to the finer qualities of seed containing a very large proportion of fixed oil, in addition to volatile oil and sulphur compounds, which enter readily into chemical change under adverse circumstances. Natural mustard seed, like other products of the soil, differs enormously in value according to the locality of growth, season, harvesting, &c., but it is an invariable rule that the better the quality of the seed the more readily is this unfavourable decomposition induced. In order to make a satisfactory table mustard, or even an article for medical use, it is necessary, as has been above stated, to have a mixture of the two kinds of seed (*S. nigra* and *S. alba*), because the white seed, although possessing very little pungency, has within it a peculiar ferment, which develops the pungent flavour contained in the black seed, and it is upon the judicious mixture of these two sorts of seed that the quality of the mustard must depend, and, in fact, this is the art of the mustard manufacturer. It is evident from what has been said as to the difference in market value of seeds that a perfectly genuine mustard may be produced at very varying prices. The black seed, being much the dearer of the two, finds its way sparingly as a rule into the lower qualities of the mustard sold to the public, and some makers, who make a

great point of manufacturing only genuine mustard, do in fact send out a pure article, but necessarily deficient in the true mustard flavour, that is to say, having little or no black mustard, because a large proportion of this seed would render the article very susceptible to change, and is, moreover, of greater pecuniary value.

The above remarks state the case put forward in favour of the manufacture of mustard as it has long been carried on. It is but right, however, to say that several well-known food analysts strongly condemn the prevailing custom. Dr. Hassall, for instance, after giving the analyses of a considerable number of samples of genuine mustard of different qualities, and of mixed or "adulterated" mustard, thus sums up his views:—

"It has already been pointed out that the turmeric is added to the mustard simply for the sake of its colour, and to cover and conceal the addition of the wheat flour. In favour of this addition it is believed that not a single reason can be adduced, except possibly that its use allows of the addition of a larger quantity of brown mustard-seed than could otherwise be employed at a given price, and that thus the public gain an advantage, wheat flour being, of course, cheaper than white mustard, which again is less costly than brown mustard; but this difference in the cost must really be very inconsiderable, and if obtained at the expense of the purity of the article, the practice should be abandoned. At all events, it is wrong and misleading to call these mixed articles by the name of mustard. By making mustard in all cases either entirely of the brown seed or of admixtures of the brown and white seed, a wide range in the qualities and prices of mustard is obtained and the mustard in which the white seed greatly predominates can be sold, we know, at a very low price. We trust, therefore, that the time has now arrived for the abandonment of the use of wheat flour and turmeric in the manufacture of mustard, and that, if the sale of the mixtures still be allowed, the law will continue to render it compulsory that the mixed articles should be sold only as

mixtures, and not under the name of mustard simply. We even regard the manufacture of several varieties and qualities of the same article, as mustard for example, a very great evil, and the public suffers in pocket to a large extent thereby, the lowest qualities of these mixtures being constantly sold at the price of the higher, and especially is this the case in poor neighbourhoods. This is an evil which, so far, has been but little dwelt upon, but it is nevertheless most serious, and it vitiates the trade in the articles mustard, cocoa, and vinegar."

The actual process of manufacturing mustard is not a very complicated one, but, as before stated, careful management is required to ensure the best results as to flavour and keeping qualities. Suffice it to say that the seed is crushed between rollers, pounded, sifted, and resifted into various qualities such as "superfine," "fine," "seconds," &c.

One of the most interesting features in the Machinery in Motion Department of the Health Exhibition is that contributed by the firm of Messrs. Colman, who show the whole process of mustard manufacture. They are the largest manufacturers of this condiment, and it may be truly said that there is hardly a remote corner of the world to which, like English beer, their product does not find its way. Their works at Norwich cover over 15 acres, and they employ over 2,000 hands. Their foreign trade is enormous, and perhaps some readers may be surprised to hear that in Paris English mustard is almost as popular as the French varieties, while in some French towns its consumption is even greater than that of the native product. This is probably the result of Messrs. Colman having shown their process at the Paris Exhibitions in 1867 and 1878, much in the same way as they are now showing it at South Kensington.

French mustard is chiefly made at Dijon, and as is the case with other continental mustards, is mixed with tarragon and other vinegars flavoured with a variety of herbs, spices, and other substances, with walnut or mushroom ketchup, or the liquors of the richer pickles. Hence they

have not the same pungency as our ordinary table condiment.

The common practice of preparing mustard for the table with vinegar, or still more, with boiling water, materially checks the development of those peculiar principles on which its pungency or strength almost entirely depends. To economize this substance, we should use lukewarm water only; and when flavouring matter is to be added to it, this is better deferred until after the paste is made.

Mustard is valued medically for poultices and also as an emetic, but beyond these uses it does not seem to be held in as high esteem as it was formerly. A few years since the use of mustard seed, by spoonfuls, *ad libitum*, was a common and fashionable remedy in torpor or atony of the digestive organs. The practice was a revival of that recommended by Dr. Cullen; but it has now again sunk into disuse. Sir John Sinclair also approved of the use of mustard seed in this way, especially for the preservation of the health of the aged.

At the same time, however, dietetic authorities seem generally agreed that the moderate use of table mustard is not only innocuous, but that it stimulates and assists the digestive organs when suffering from inactivity. Our forefathers appear to have used it as a condiment with more food substances than we now generally consider appropriate. Most of us would agree with the old writer in one of the earliest books published by Wynkyn de Worde at the end of the fifteenth century, who says "when you eat brawn be sure you have good mustard," and with John Russell, who in his quaint *Boke of Nurture* (Harleian MS. in British Museum) notes that "Brawne with mustard is concordable." But we should demur to his advice to eat it with "feysand, partriche, and cony," or with "samoun" (salmon), and a variety of other fish, as he recommends. Among the recognized palatal proprieties at the present time is the association of mustard with pork and beef, in the various forms in which they are served, but not with veal, mutton, or the white flesh of birds; and still less so

with oysters or roast hare, though with these last-named delicacies two friends of the writer always eat the pungent condiment, much, it must be confessed, to his astonishment, and in spite of his endeavours to educate them out of these startling improprieties and offences against the canons of æsthetic gastronomy. But perhaps it must be allowed that this is "only a matter of taste:" and it will not do to contravene the old adage *de gustibus non est disputandum*, or, since other condiments have yet to be considered, further in this direction to "trifle one's time away," as the French have it—*s'amuser à la moutarde.*

CHAPTER X.

PEPPER.

In common parlance there are three kinds of pepper in domestic use as condiments, viz.—black, white, and red or cayenne. This nomenclature, however, is not, strictly speaking, correct, as black and white pepper are produced from one and the same plant, and cayenne is not from a "pepper" plant at all.

The natural family of *Piperaceæ* includes four plants of great utility to mankind. Two of these, *Piper nigrum*, or black pepper, and *Piper longum*, more recently named *Chavica Roxburghii*, or long pepper, are chiefly employed for dietetic and culinary purposes; whilst others, *Piper cubeba*, now *Cubeba officinalis*, and *Artanthe elongata*, or the matico plant, are principally employed in medicine; and others again as narcotics.

The pepper of commerce is furnished by *Piper nigrum*, and it is this species which now specially concerns us. It is indigenous to the forests of Travancore and Malabar, and is cultivated both in the East and West Indies, in Sumatra, Java, and other islands; and is a shrubby, climbing plant, which attains the height of from eight to twelve feet. The berries, or peppercorns, grow on terminal flower-stalks or spadices; they are at first green, but change subsequently to red and then to black. When any of the berries on a spadix have begun to turn red, the whole are gathered, dried in the sun, and the stalks separated by the hand. In drying, the succulent part of each berry becomes contracted and wrinkled, forming a hardened, wrinkled cortex; the corrugations being much raised, and describing a kind of elevated net-work. It climbs to the height of twenty feet, but is said to bear best when restrained to the height of

twelve feet. It begins to produce at about the third year, and is in perfection at the seventh; continues in this state for three or four years, and declines for about as many more, until it ceases to be worth keeping. The fruit grows abundantly from all its branches, in long small clusters of from twenty to fifty grains; when ripe it is of a bright red colour. After being gathered, it is spread on mats in the sun, when it loses its red colour, and becomes black and shrivelled as we see it. The grains are separated from the stalks by hand-rubbing. That which has been gathered at the proper period shrivels the least; but if plucked too soon, it will become broken and dusty in its removal from place to place. The vine produces two crops in the year, but the seasons are subject to great irregularities. Those berries are the best which are not too small nor too much corrugated; which are heavy, and sink readily in water.

White pepper is produced by the same plant as the black pepper, and is prepared by allowing the berries to ripen, keeping them for three days in the house after gathering, washing and bruising them in a basket with the hand till the stalks and pulp are removed, and then drying the white seeds. Sometimes white pepper is prepared from black by removing the dark outer layer of pericarp. The article is most largely prepared in the Straits, but the finest is produced in Tellicherry. China is the greatest market for it.

The active properties of pepper depend upon the presence of *an acrid resin*, *a volatile oil*, and a crystallisable substance called *Piperine*.

The use of white pepper instead of black is an instance of the sacrifices made to please the eye. Pure white pepper has only about one-fourth of the strength of pure black pepper, whilst it is nearly destitute of the fine aroma of the latter. It also contains a mere trace of piperina or piperine, one of the most valuable constituents of black pepper. Black pepper owes its pungency to about 2 per cent. of its essential oil; and it contains about 2¼ per cent. of piperine.

Its whole constituents, as given by Pelleter, are acrid soft resin; volatile oil; piperine, extractive, gum, bassorin, starch, malic acid, tartaric acid, potash, lime, magnesia and salts; and woody fibre.

"Long Pepper" consists of the unripe spike or fruit produced by two other species of *Piper*, namely: *P. longum*, a native of Malabar; and *P. officinarum*, a native of the Indian Archipelago. In its general properties it resembles black pepper, but is less aromatic, though equally pungent. Elephant pepper is merely a larger variety of this species. The root and stems, sliced and dried form the "pippula moola" of India.

Jamaica pepper is made from the unripe berry of the *Eugenia pimenta*, which grows in the West Indies to the height of 20 or 30 feet, and bears flowers of an aromatic odour. The berries are gathered when green, and most carefully dried, after which they are of a brown colour. The flavour is much less pungent and more aromatic than that of black pepper, and is so rich as to be called allspice.

There is no need to mention any other species of pepper, nor the varieties of black and white pepper as distinguished and sold by wholesale dealers, nor again the flavoured or "scented" peppers, which are only the ordinary peppers of commerce with names indicating the additions made to them, or bearing mere fancy appellations. It is with the ordinary condiment of our cruet-stand that we have mainly to do.

Unfortunately from its very constitution so to speak, or rather from the form in which it is sold, our pepper specially lends itself to adulteration. It has been found mixed with rice, sago, potato starch, linseed meal, chilis, husks of red and white mustard, wheat bran and flour, and ground gypsum or crystallised sulphate of lime. The stock material for adulterating pepper is the husks of red and white mustard seeds and linseed meal, warmed up with chilies. Add to these P. D., which is the symbol in the trade for another "assistant" signifying "Pepper Dust," consisting either of the sweepings of the warehouses, or else

of an article made up in imitation of ground pepper, and expressly used for the adulteration of that article.

This is a terrible list, but we may take courage in the belief that adulteration of our black pepper is not now practised to any very great extent, and that what we get at "respectable" shops fairly answers its purpose and is not injurious.

Black pepper has long been held to have medicinal virtues, and as a medicine it is often serviceable in nausea, vomiting, chronic diarrhœa, and agues. In North America a common remedy for the last is $\frac{1}{4}$ oz. of ground pepper stirred up with a glassful of warm beer: or a like quantity made into a tincture by steeping it in 5 or 6 times its weight of gin, rum, or whisky for a few days.

As a condiment it is carminative, anti-spasmodic, and at the same time stimulant, affording some little relief in cases of deranged functions, especially with regard to the digestion of vegetables. Like most other ordinary condiments it may safely be said to assist the digestion of persons in a normal state of health, if taken in moderation. It is freely used throughout the world, and seems to meet an instinct of taste in civilized man. It was not taken by our ancestors as freely as mustard, for the simple reason that it was not so easily obtainable two or three centuries ago as it is now. As regards its appropriateness as a condiment with various kinds of food, it is safe to say without controversy and in a general way that it seems the most approved of when taken with those articles which demand the accompaniment of salt.

The plant from which cayenne is made, as has been already noticed, belongs not to the botanic order of the *Piperaceæ*, but to the *Capsicum* genus, in which is classed the *Solanaceæ* order, including such apparently diverse members as the potato, the tomato, and tobacco. Cayenne pepper consists of the pods or seed vessels, ground and reduced to powder, of different species of *Capsicum*, but principally of *C. annuum*, *C. baccatum*, and *C. frutescens*; and it is the latter species, being stronger and better flavoured, which yields

the best description of cayenne pepper. *Capsicum annuum* is a native of America, but is cultivated in the West and East Indies, and to some extent in greenhouses in England and other European countries. It is an annual herbaceous plant, and one of the hardiest and most productive found in tropical climates, growing luxuriantly in almost all dry soils, however indifferent. In this country it was grown as far back as the end of the 16th century. It flowers in July, and ripens its pods in October. When immature the berries are green, and only gradually become red as they grow ripe. They are used both in the green and red states, and in the undried and dried conditions; in the recent state they are employed for pickling; when dried they are used in medicine; and, reduced to powder, they constitute cayenne pepper. The pods of this capsicum are hot and pungent, but they have no aroma. The pods of *Capsicum frutescens* constitute what is known as *Guinea* or *Bird pepper*, and when ground they furnish the best description of cayenne pepper. They are small, scarcely an inch in length, a line or two broad, and of a deep orange-red colour. Each pod encloses about a dozen flattened, reniform seeds. The pods are hotter and more fiery than those of *C. annuum*.

The following is an analysis of capsicum berries by Bucholz:

Acrid soft resin (*capsicin*)	4·0
Wax	7·6
Bitter aromatic extractive	8·6
Extractive with some gum	21·0
Gum	9·2
Albuminous matter	3·2
Woody fibre	28·0
Water	12·0
Loss	6·4
	100·0

Capsicin is the active principle of cayenne, and so pungent is it that a very minute quantity, even as little as half a grain, diffused throughout a room will set a whole party of people sneezing.

It is painful to think of the adulteration to which cayenne pepper is so easily subjected. The list of "foreign substances" often mixed with it is very formidable. An authority says that the red pepper of the shops is often a spurious article, made by grinding a mixture of any of the reddish woods or sawdust with enough red pods or chilies to render the mixture sufficiently acrid and pungent. Common salt, colcothar, red bole, brick-dust, vermilion, and even red lead, are also common additions. It is even more adulterated than ordinary black and white peppers; and ground rice, turmeric, red earths, and salt are found in it in addition to the substances already mentioned. Most of the ordinary adulterants fortunately only affect the purchaser's pocket and not his health; but, as Dr. Hassall says, the adulteration of cayenne with such substances as red lead and mercury is, doubtless, highly prejudicial to health. It has been stated that colic and paralysis have both been produced by the use of cayenne containing red lead. The salts of lead and mercury are characterized by the circumstance that they are apt to accumulate in the system, and so to produce symptoms of a very serious nature. Thus, no matter how small the quantity of mercury or lead introduced each day, the system in the end is slowly and insidiously brought under the influence of these poisons, and thus becomes seriously affected.

We must hope that matters are not practically as bad as professional analysts aver, and that our cayenne, when purchased from shops which have a character to lose, is generally of a fair standard. When it is so, it may safely be used as a condiment by persons in ordinary health. But red pepper acts in some instances as an irritant. Where the lining membrane of the bowels is in a state of relaxation, as in summer diarrhœa, the action of this pepper is more directly astringent, but this action is only produced when administered occasionally. If habitually taken, cayenne pepper produces a congested condition of the whole alimentary canal, and particularly, engorgement of the liver. As a rule, dyspeptic patients had better avoid much cayenne.

There are other kinds of cayenne of which the space at disposal only admits a passing reference. There is, for instance, the Nepaul cayenne, the best quality of which is ground in that country and sent away in tins. The Hungarian paprika is another variety, something like the Nepaul pepper, the product of the *Capsicum annuum* as grown in Hungary. It is in high esteem in that country, and enters very largely into its cookery, which, without intending any reflection on it, is of rather a greasy character. Paprika is generally divided into four classes, according to its strength and colour. Samples of these can be seen in the Austro-Hungarian Court of the Health Exhibition, shown by Markó & Weyden of Budapest, the largest dealers in such commodities. The Hungarian paprika would probably suit English tastes if trial were made of it.

Pepper is often mentioned by our old writers. Sir T. Elyot, for instance, in *The Castel of Helth* (iii. 17), speaks highly of it as a healthful condiment:— "The nature of *pepper* is, that beinge eaten it passes through the bodye, heatying and comforting the stomacke, not entrynge into the vaynes or annoyinge the lyuer." But Holland (*Plinie*, xii. 7), depreciates it thus:— "A fruit or berrie it is (call it whether you will) neither acceptable to the tongue nor delectable to the eye; and yet for the biting bitterness that it hath, we are pleased therewith, and we must have it fet foresooth as farre as India. What was he, gladly would I know, that ventur'd to bite of *pepper* and use it in his meats? Who might he be that, to provoke his appetite and find himself a good stomacke, could not make a shift with fasting and hunger only."

We find pepper mentioned in Shakespeare coupled with vinegar (*Twelfth Night*, iii. 4) in the metaphorical sense of irritability. In a similar way we use the adjective "peppery" now. The verb to "pepper" had the early signification of "pelting as with pepper-corns," and so to "hit in many places," and to "wound smartly." We find this use more than once in Shakespeare; for instance,

Falstaff (1 *Henry IV.* v. 3.) speaks of his "ragamuffins" being "peppered"; and Romeo (*Romeo and Juliet*, iii. 1), says "I am peppered I warrant for this world: a plague on both your houses!" We still recognise this metaphorical use, and as a slang term, "give him pepper" is a common one.

CHAPTER XI.

VINEGAR.

VINEGAR, in some form or other, and produced by a variety of methods, is one of the oldest condiments of the world. We read of it in the Bible History of Ruth (Ruth ii. 14), and in the New Testament (Matt. xxvii. 34 and 48), but the "vinegar" here mentioned is probably rather a sour wine than what we strictly understand by the term. This remark may possibly apply to many passages in old authors where our translation of the word "vinegar" is hardly the correct one; though practically sour wine (*Vin aigre*), if it has undergone fermentation, is vinegar; and we must remember that the ancients well knew that the juices of fruits, after becoming vinous, i.e., alcoholic from fermentation, were subject to another change by which they were rendered sour. Vinegar was in use by the Greeks and Romans in Classic times. The Roman soldiery when campaigning mixed it with water as their ordinary drink, and we all know the myth of Hannibal forcing a pass for his army through the rocks of the Alps by the application to them of vinegar. In later days Frederick the Great had each soldier supplied with it, and doubtless its use preserved thousands of men from the deadly effects of forced marches and unmedicated ditch water.

All liquids capable of vinous fermentation may be made to produce vinegar, but in all such cases the sugar is first converted into alcohol, and alcohol, by oxidation, into *acetic acid*—the acid of pure vinegar. It is to the presence of this volatile principle that vinegar mainly owes its aroma and pungency.

Vinegars may be classified according to their different sources; but, it would answer no good purpose to enter minutely into the various processes used in their production. Suffice it therefore to say that in the manufacture of malt vinegar a mixture of malt and unmalted grain is mashed with hot water, and the resulting wort fermented, as in the common process of brewing. The liquor is then run into barrels, placed endways, tied over with coarse canvas, and arranged side by side in darkened chambers, moderately heated by a stove, and freely supplied with air. Here it remains till the acetous fermentation is nearly complete, which usually occupies several weeks, or even months. The newly formed vinegar is next run off into two large tuns, furnished with false bottoms, on which some "rape" (the pressed cake from making domestic wines, or the green twigs or cuttings of vines), is placed. One of these vessels is wholly, and the other only about three-fourths filled. The fermentation recommences, and the acetification proceeds more rapidly in the latter than in the former tun, and the liquor it contains consequently matures the sooner. When fit for sale, a portion of the vinegar is withdrawn from the smaller quantity, and its place supplied with a like quantity from the full tun, and this in its turn is refilled from the barrels before noticed. This process is carried on with a number of tuns at once, which are all worked in pairs. This vinegar usually contains a small quantity of sulphuric acid, the presence of 1–1000th part of which is allowed by law. Malt vinegar in this country is darkened in colour by caramel to suit the fancy of consumers.

Wine (French) vinegar is prepared in wine countries from grape juice, and inferior new wines, worked up with wine-lees, by a nearly similar process to that adopted for malt vinegar. That prepared from white wine (white wine vinegar) is the most esteemed. It is purer and pleasanter than malt vinegar, and it usually contains from 5 to 6° of acetic acid. Wine vinegar is of course either white or red, according to the colour of the wine from which it is

prepared. It is held to be superior to the other kinds of vinegar, as it contains the flavour and aroma of the wine from which it has been made. It is sometimes flavoured by the addition of the wine, the presence of the alcohol increasing its aroma and pungency.

The German, or "quick-method" of making vinegar is based upon the fact that acetification is the mere oxidation of alcohol in contact with organic matter. Hence, by employing dilute alcohol, or liquors containing it, and by vastly enlarging the surface of the liquid exposed to the air at a proper temperature, the period occupied in acetification may be greatly reduced. The process is conducted in large vats, capable of each holding from 6,000 to 10,000 gallons of wash; each vat is half filled with the liquid to be acetified, and the upper half with bundles of birch, such as are in general use for brooms. The pump in the centre elevates the liquor, and, by means of its rotative motion, disperses it in a shower over the surface of the bed of birch, and in descending through the same it is met by a small ascending current of atmospheric air, which, coming in contact with the multiplied surfaces of the liquor trickling through the twigs, speedily acetifies it; the whole being kept up to the proper heat by a steam-pipe of pure tin passing through the vat. The acetification is generally completed in twenty days, but varies in inverse ratio to the proportion of birch to the wort to be acetified; and the whole operation, mechanical and chemical, being performed by steam, no manual labour of any kind is required, save the occasional inspection by the manager to ascertain when the process is finished.

Vinegar is frequently prepared on a large scale from sugar, beet, and cider, as also occasionally from fruits other than the apple, as pears, gooseberries, currants, &c. The vinegar made from apples, pears, and other fruits is distinguished by the presence of malic acid. Dr. Stenhouse has even recommended the use of seaweed for the manufacture of vinegar. This, when subjected to fermentation, with the addition of lime, yields acetate of lime, which may

be decomposed with sulphuric acid, thus furnishing a more or less pure acetic acid.

By submitting wine or malt vinegar to distillation, the acetic acid and all the volatile constituents are obtained in the distillate, which is known as distilled vinegar. It should be remembered, however, that the vinegar thus obtained is always weaker than that from which it is derived, and this because the boiling-point of vinegar is higher than that of water. The distilled vinegar of wine often contains a small quantity of alcohol.

The various flavoured, or spiced vinegars used as condiments, but mainly employed in cookery, are sufficiently indicated by their titles, such as tarragon, chili, capsicum, horse-radish, garlic, &c., &c.; while the flavoured vinegars known as raspberry, cowslip, &c., &c., are merely beverages; but it may be noted that the sugar added to them is in a great measure converted into vinegar, while the fruits contribute in some cases a proportion of it, but chiefly their peculiar flavour.

Nearly all vinegar manufacturers supply at least four different strengths or qualities of common vinegar, but as the numbers attached to their productions do not indicate absolute but relative strengths, the vinegars of different makers having the same number vary considerably in the amount of acetic acid contained in them. Good vinegar should contain 5 per cent. of anhydrous or pure acetic acid.

The principal adulterations of vinegar are, according to Dr. Hassall, with water, sulphuric acid, burnt sugar, and sometimes with acrid substances, as chilies and grains of paradise, and also with acetic and pyroligneous acids. The water is added to increase its bulk, sulphuric acid and acrid substances to make it pungent, and burnt sugar to restore the colour lost by dilution. Some of the vinegars sold at small huckster's shops, and at oyster stalls, consist of little else than diluted sulphuric acid, and water coloured with burnt sugar. Now, the law allows the addition of one part of sulphuric acid to 1000 of vinegar, and it is only when the quantity exceeds that amount that it can be considered

as an adulteration; and this it very frequently does. T
use of this quantity of sulphuric acid was permitted on t
plea, urged by the manufacturer, that it was necessary
order to make the vinegar keep. That it is not requisite
the preservation of well-made vinegar is shown by t
circumstance that several manufacturers, especially tho
who make use of the quick vinegar process, do not u
sulphuric acid at all; and yet the vinegar made by the
keeps perfectly well. As has already been noticed, t
same practice prevails in the article vinegar as in mustard
no less than four, and even five qualities of vinegar bein
made, differing only in strength. The consequence
this system is, that of vinegar bought at several differen
shops, some will be found to contain two or three time
less acetic acid, the active ingredient of the vinegar, tha
others, although the same price is paid for them all. Th
system, therefore, affords great facilities for impositio
Very commonly, after the manufacture of the vinegar h
been completed, the strength is brought up by an additio
of acetic acid. Dr. Hassall is of opinion that this practic
is to be regarded as an adulteration. To allow of th
addition would be to acknowledge that a mixture of aceti
acid and water really constituted vinegar, which is far fro
being the case, since genuine vinegar contains extractiv
matters of different kinds as well as certain volatile princi
ples, and which affect both the aroma and the flavou
Other adulterations described in books, the majority
which are probably of unfrequent occurrence, consist in th
addition of nitric, hydrochloric, and tartaric acids, alu
salt, spurge flax, mustard, pellitory, and long peppe
Vinegar is not unfrequently contaminated with arsenic, th
being introduced through the sulphuric acid used in i
adulteration.

Notwithstanding these adulterations, many of which D
Hassall detected in the samples he analysed, vinegar o
excellent quality and at a moderate price may now b
obtained in every part of the country, so that it is no longe
necessary to make it at home; but the following receipt wi

produce it; viz., 1 gallon of water, 1¼ lb. of raw sugar, and ¼ pint of yeast. At a temperature of 80° it will be sufficiently acid in three or four days to be drawn off, when an ounce of cut raisins and the like weight of cream of tartar should be added, and after a few weeks the sweet taste will have entirely disappeared, so that the fluid may be bottled. A more simple method for the production of a small quantity is to procure the vinegar plant (*Penicillium glaucum*) and place it in a weak solution of sugar in a warm place for a few days. The same plant will continue to increase and may be used again and again for the same purpose. The production of vinegar from any saccharine material is accompanied by a fungoid plant, so that vinegar produced in the purest manner from wine-lees deposit a material called "Mother of Vinegar," which is a mycoderm, *Micodermi vini*, and when added to weak alcohol produces vinegar. It consists of cellulose and a nitrogenous principle. The process has, however, some connection with the extractive substance of plants, for when that of wine is lost by age the acetous fermentation is not easily produced. Among the most reliable vinegars now offered to the public are those bearing the names of Champion, Sarson, and of Messrs. Hills and Underwood.

The medical use of vinegar is well known, but, generally speaking, it is not so highly esteemed as it was in the generations which have immediately preceded us, its value as a remedy for hiccough, blood-spitting, and, when boiled with honey, as a gargle for sore throat, or as a mixture for cough, not being so fully recognised as it once was. Its use, however, for sprains and bruises, for its cooling and reviving properties when applied to the face of persons suffering from great heat or from fainting, is fully acknowledged, while for toilet and veterinary purposes (if it be not wanting in good taste to class these together) there are a variety of ways in which it does good service. Nor should its value as an antiseptic and food preservative be forgotten, its efficacy in reference to "soused" or "pickled" fish being very marked.

But it is with the use and value of vinegar as one of
common condiments—a member of the domestic cru
stand—that we are more immediately concerned. The
seems to be a very widely spread craving for more or le
of palpable acid of some kind or other among the inhab
tants of almost all countries of the world. The tot
quantity of vinegar consumed in this country is muc
greater than is usually supposed, especially among tho
whom we term the middle and lower classes, and pa
ticularly among the latter, who have probably been led t
use it extensively as a kind of set-off to their tasteless an
distasteful food. It may, therefore, be ranked as a valuab
food accessory, second, perhaps, only to salt. When take
in small quantities acetic acid, if not too strong, exercises
digestive influence upon the gelatinous constituent of th
harder portion of meat. Cold meat creates a demand fo
some such solvent, and pickles, in which vinegar is th
principal element, supply this requirement.

Vinegar also, especially when combined with oil, enabl
uncooked vegetable matter to be digested by thousand
who could not tolerate raw vegetables without it; th
acidity of the vinegar being counteracted to some exte
by the smoothness of the oil, while the oil is rendered mo
palatable by the vinegar, and in addition to its food valu
acts as a mechanical lubricant to the intestines. At th
same time, however, although the acetic acid is transforme
into carbonic acid, and so far is a food, it would be a refine
ment to say that vinegar supplies nutritive materials; an
therefore it is not safe to go further than to say that its chie
and almost sole use is to flavour food and stimulate th
nerves of taste.

As in the case of mustard and pepper we must no
attempt to lay down any hard and fast line as to th
particular kinds of food with which vinegar is most appro
priately eaten. *Chacun à son goût;* but few of us would b
disposed to agree with the author of "Boke of Nurture"
quoted in the two previous chapters who suggests it as a
condiment for goose (goos), and roast beef (roost beef)

though, as a matter of fact, we do use it with the latter when it is accompanied with horse-radish sauce and beet-root.

Like several other condiments, vinegar is mentioned in the old dramatists, and has in many nations given rise to proverbs, proverbial sayings, and metaphorical expressions. Sir Andrew Aguecheek, in Shakespeare's *Twelfth Night* (iii. 4), says "Here's the challenge, read it; I warrant there's vinegar and pepper in't." In the *Merchant of Venice* (i. 1) Salarino speaks of human beings of "vinegar aspect." And so we have the expression now of "a sour look." Both among the Greeks and Romans there was the same metaphorical use of vinegar, but with the latter the word *acetum* (vinegar) had metaphorically not only a bad meaning but a good one; at least as we gather from Plautus it was used something like *sal* (salt) to signify "pungent wit."

CHAPTER XII.

SAUCES—PICKLES—CURRIES—SPICES.

HAVING now passed in review the condiments which are the ordinary occupants of our cruet stands, and in most general use, a few concluding words in reference to some few other food accessories may not be inappropriate. Their name is "Legion," if the word condiment be taken to include all "substances used with food to season or improve its flavour, or to render it more wholesome and digestible;" but, as intimated in the Introduction, such a wide field as this could never be covered in a handbook like the present, which has already exceeded the space originally contemplated.

Sauces are certainly condiments in the sense of the word, as signifying "concoctions," or combinations of various substances which make a homogeneous whole. In classic times pungent sauces were considered as necessary for most kinds of fish, as they are now, and Greek and Romans *bons vivants* were very particular about their *garum* and *alec.* Both these celebrated sauces were manufactured from fish, and salt of a highly aromatized kind was very largely used in their production. Garum was originally made from a fish called by the Greeks *garon*, but only known at Rome in Pliny's day as a sauce. That manufactured from the mackerel of New Carthage, and further named "*garum sociorum*," (Allies' Sauce) in supposed compliment to the Spaniards, then in alliance with Rome, was reckoned the best. Strabo bears testimony to the excellence of the Carthagena sauce; but the article soon came to be imitated in Italy out of Campanian scombers, and other sea fish, till, as the demand increased, a great variety of fishy compounds came to be

offered to the Latin public, each bearing on the bottle a label with the old name, and pretending to be concocted form the original recipe. These imitations, as we learn, were of very unequal merit, the liquor sometimes running thick and turbid, as the epithet applied to it, *fæcosum*, sufficiently indicates; but in general, though varying greatly in taste, quality, consistence and colour, they were defecated and clear. Garum was everywhere held in the highest esteem, and notwithstanding the number of different fish used in the preparation, the demand was so constant that dealers sought to increase the quantity, and heighten the flavour, by mixing with it a variety of other fluid ingredients, as oil, wine, vinegar and waters. Hence recognised "brands," took the several names of "elaiogarum," "oinogarum," "oxygarum," and "hydrogarum," which were used not only as fish sauces, but as liqueurs to stimulate the appetite, and we are told—

> "That all the topers, to prepare 'em,
> Drank every man his glass of garum."

Some garum, of an expensive kind, costing, as Pliny tells us, as much as five hundred sesterces a gallon, was made from the blood of the thunny and other fish, and those who made a present of a flask of it to friends, generally took care to allude to its value:—

> "Of scomber's precious blood I send
> A *garum'd* bottle to my friend;
> Costly and thick, the last that dript
> From bleeding gills and entrails ript."

Alec, like garum, was at once the name of a fish and of a sauce made from it. This differed from the garum only in being thicker, being generally made from the dregs and feculence which remained after the garum liquor had been decanted off clear. The fish originally used for this sauce is said to have been the "halecula," though many other small species were afterwards pressed into the service, salt being largely employed. The halecula was a small and comparatively worthless fish for eating, but of strong

tured by the Greeks at Constantinople. S
have been made to revive ancient sauces in
and Rondolet, in particular of one, bearing
parison with the best of those gone by
preparing it was to macerate anchovies in
well spiced and seasoned with chopped pars
fire, till the whole was dissolved. He writ
gerum" with enthusiasm, declaring it "
savoury, and fit to set before a king."

The sauces offered to the British publ
"infinite variety" that we might almost say—
tot sauces." The names of many are very
to extensive advertisement, often accompan
artistic illustration. Several have quite a h
to them as regards their "invention," and po
tive character; but it is not far from the tru
many of them are "very much alike." This
from the fact that the basis of so many p
made not only in this country but on the Co
This useful condiment is prepared by the
Japanese from the fruit of the *Soja hispida*,
important place among the oil-yielding plant
is prepared by boiling the beans with an equ
roughly-ground barley or wheat, and leaving

Japanese, its quotation being from about *2s. 3d.* to *3s.* per gallon.

A famous wit and gourmet, when dining in company with three most distinguished men of science, is recorded by Brillat-Savarin to have said :—" I consider the discovery of a new dish as a far more interesting event than the discovery of a star ; for dishes increase the sum of human enjoyment, whereas there are always plenty of stars to be seen." The inventor of a really new sauce would win the suffrages of the gastronomic world, and for ever be looked upon as a benefactor to his species ; though we must not forget the old adage that " hunger is the best sauce."

Sauces of all kinds offer great facilities for adulteration, and for production from worthless or unwholesome substances. The foolish notion that soy is often obtained from a decoction of black-beetles or cockroaches is hardly worth mentioning ; but treacle and salt are employed in the fabrication of a spurious article. In anchovy and other red sauces and pastes " bole armenian " is used for colouring purposes, but not to the same extent it was some years ago. The ferruginous substance just named is a natural earth, containing a large quantity of the red oxide of iron : but frequently an article is made in imitation of it, consisting of a mixture of Venetian red and chalk. Of this red earth or dirt, as much as from 10 to 15 lbs. have been added to 100 gallons of anchovy sauce. Perceiving clearly the evils connected with the employment of artificial colouring matters, many of the most respectable manufacturers have, to a very great extent, abandoned their use, except in the case of anchovy sauce, which they state to be almost unsaleable without a small quantity of colouring matter. The difference between the ordinary coloured, and the uncoloured sauce is very striking, the former being bright red, and the latter of a dull pinkish colour. Moreover, the use of colouring matter involves considerations of cleanliness, and this is especially the case with anchovy sauce. The quantity of refuse and dirt in the fish from which it is prepared is very great, and they are exceedingly difficult of

Another sauce of a very unreliable char
ketchup. Large quantities of this on chem
tion are found to abound with copper.
condiment is said to be often nothing else th
left behind after the process employed
distilled vinegar, subsequently diluted with
the outer green husk, and seasoned with all
pepper, pimento, onions, and common salt
ketchup also is often very doubtful as to it
not unfrequently quite innocent of mushroom
commodities are better made at home from
in standard cookery books, or obtained dir
farmhouse where they pride themselves on proc
ketchups. Dwellers in London, and other la
population should, however, be on their
"young men from the country," and for the
against old men and women too, with an assu
and dress who occasionally call from hous
quiet streets, and offer "real farmhouse-made
a very tempting price. The ketchup is "hon
tainly, but is manufactured in Whitechapel, B
some such locality.

As a rule, a moderate quantity of good sau
fish or meat is not unwholesome, but rather
as by giving a relish to food, it sharpens th

in many ways, particularly if they are cheap pickles of inferior vegetables put up with inferior vinegar, and adulterated with copper. Moreover, pickles in themselves are not very digestible.

It might be thought that all must be straightforward as regards the vegetables used; but "gherkins," on close examination, sometimes turn out to be but shrivelled or sliced cucumbers: "young tender beans" to be old and tough; the "cauliflowers" to have run to seed, and the "red cabbage" to be nothing more than white cabbage turned into red by colouring matter, as a dyer would change the colour of a dress; while vegetable marrows and sliced turnips sometimes do duty for more aristocratic vegetables.

But the adulteration of pickles is of more consequence, as this is a question of the quality and composition of the vinegar used, and the means employed for preserving and heightening the colour of green pickles. From Accum's well-known work "Death in the Pot," the following information is given in reference to the "greening" of pickles: "Vegetable substances preserved in the state called pickles, by means of the antiseptic power of vinegar, whose sale frequently depends greatly upon a fine lively green colour, and the consumption of which, by seafaring people in particular, is prodigious, are sometimes intentionally coloured by means of copper. Gherkins, French beans, samphire, the green pods of capsicum, and many other vegetable substances, oftener than is perhaps expected, are met with impregnated with this metal. Numerous fatal consequences are known to have ensued from the use of these stimulants to the palate, to which the fresh and pleasing hue has been imparted according to the deadly *formulæ* laid down in some modern cookery books, such as boiling the pickle with halfpence, or suffering them to stand for a considerable period in "brazen vessels." In some cases copper, usually the sulphate, commonly known as *blue stone*, is added direct to the vinegar. More frequently, however, no direct addition of copper is made, but

a sufficient quantity of that metal in the form of an acetate is obtained by the repeated boiling of the vinegar in copper vessels; but since vinegar is so frequently adulterated with sulphuric acid, sulphate of copper is generally formed as well. Thus it amounts to the same thing whether the copper is added direct to the pickles, or whether it is taken from the copper utensils by the action of the acids in the vinegar.

The presence of copper in pickles can of course be detected by various chemical tests, but it is often unmistakably indicated by their colour. When the housekeeper makes her own pickles, they are usually of a yellow colour rather than green, but as exhibited in shop windows they frequently present a vivid bluish-green colour, more intense than that of the fresh vegetables. Whenever pickles are of a very decided green, they will almost always be found to contain copper, but when they are yellowish or brownish-green, copper is not present. Vinegar of good quality ought to contain from 4 to 5 per cent. of pure acetic acid; but the vinegar with pickles has often been found of a very weak description, the percentage of acetic acid ranging from 1·48 to 2·91. Of course it is an adulteration when free sulphuric acid beyond the proportion allowed by law in vinegar is found in pickles.

It is most satisfactory to know that a very great improvement has been made in the manufacture of pickles during the last few years, and the practice of "greening" them has very generally been abandoned. The productions of high-class manufacturers, whose names are familiar to most of us, may be thoroughly depended on.

Pickle-making, it appears, is to a great extent independent of the seasons; and most of the different kinds of pickles may be made at any period of the year, as manufacturers keep a large stock of various vegetables immersed in brine. They are thus enabled to put up a regular quantity of pickles daily, and to meet a sudden demand for any special kind. Perhaps the vegetables would be better roughly stored in vinegar, but brine is used for the sake of economy.

Curries form as it were a class to themselves, and a long chapter would not exhaust the subject of their composition. Curry powder is certainly a condiment, or food accessory, and not a food. Several ingredients enter into its concoction; that of good quality containing turmeric, black-pepper, coriander seeds, cayenne, fenugreek, cardamoms, cumin, ginger, allspice and cloves. Of these different manufacturers use different proportions. The famous Ceylon curry powder is said by Dr. Balfour to have the following rather indefinite composition:—A piece of green ginger, two fragments of garlic, a few coriander and cumin seeds, six small onions, one dry chili, eight peppercorns, a small piece of turmeric, half a dessert-spoonful of butter, half a cocoanut, and half a lime. Curry powder seems an absolute necessity for the poorer natives of India and the East, who are enabled to live almost entirely on rice flavoured with a few pinches of the condiment. In this country, though much might be advanced in its favour, it is hardly ever used by the poorer classes. Some years ago the benevolent Duke of Norfolk urged its use in times of distress, but in vain. But curry in England and curry in India are two very different things, the latter whenever possible being made with freshly bruised ingredients. The great principle of curry making in the East seems to be the employment of cayenne to give heat, of fruit to give acid, and of raisins or sugar to give sweetness.

Curry powder is another of those articles which lends itself easily to adulteration, which is effected by any starch or farina, or any vegetable substance added for the sake of bulk and weight, or added mineral matters, especially those employed in the coloration of cayenne.

But notwithstanding the superiority of fresh-made curries to those prepared with the ordinary curry powders of commerce, many excellent varieties of the latter, and of substances curried in tins, are to be procured in this country. For instance, the well-known tinned curries of Mr. Halford, once chef to Lord Dalhousie when Governor-General of India, leave nothing to be desired, so exact are

they to the "native" pattern; and visitors to the Health Exhibition will find "something to their advantage" at the stands of Mr. W. Bowden, of Mr. Edmunds, and of Messrs. Wix & Sons, where they can learn much in the matter of curries, chutnies, sauces, pickles, and condiments, generally; the "Kaisar-i-Ind" Anglo-oriental pickle, and the "Criterion" sauce of the last-named firm being specially worthy of notice.

Spices form another large class of condiments in the wide acceptation of the term. They were highly esteemed from remote antiquity, and in very early times were a principal article of merchandise. They were also acceptable presents even to a king; and we read "neither was there any such spice as the Queen of Sheba gave King Solomon." So important were they even in our cold climate, that in our early history the spicery was a special department of the Court, and had its proper officers. They were necessarily rare and costly in the 14th century, since they were imported from the Levant, and were not then in general use. Chaucer and Wicliffe, and other old writers, mention many by name; and among the recorded ingredients of old recipes we find cinnamon or canella, mace (macys), cloves (clowe), galyngal, ginger, cubebs; grains of paradise (or de Parys), nutmegs, caraway, and spykenard de Spagne. These and many others are still in use among us; but being mostly employed for culinary purposes and for flavouring drinks, they hardly come under that class of condiments which have mainly formed the subjects of the preceding pages.

INDEX.

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INDEX TO VOLUME.

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